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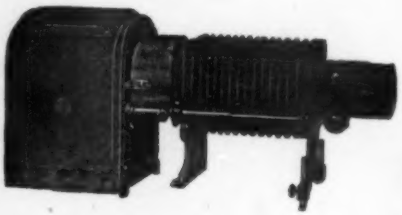

SCHOOL SCIENCE AND MATHEMATICS

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THE VALUE AND METHOD OF THE HISTORICAL ELEMENT IN THE TEACHING OF SECONDARY MATHEMATICS.

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CORRELATION AND UNIFICATION.

For the past few years there has been much said and written about the unification and correlation of the various branches of secondary mathematics, and in fact the correlation scheme is now being used in many of the larger high schools throughout the country. But whatever may be the attitude of educators in general toward the idea of a complete unification, there seems to be no objection, but rather a general approval, even by the critics of the unification plan, of the correlation of the branches of mathematics in the secondary field with the history of the origin and development of each of those branches.

It will be the two-fold purpose of this paper, therefore, to confirm the above statement concerning the attitude of educators toward the value of the history of mathematics in the teaching of that subject, and to ascertain the method by which this correlation can best be accomplished in the process of teaching.

RESULTS OF CORRELATION.

First, let us review briefly some of the tangible results that may be secured by means of the historical tool through the leadership of enthusiastic teachers who have equipped themselves in the field of history; and, if possible, answer the few objections that sometimes appear to its use.

The first and perhaps, most important result to be obtained is the stimulation of interest both to the individual pupil and to the class as a whole. The abstract subject matter of algebra and geometry, which is so mechanical and dry to the alert mind of the average high school pupil, can often be made in

this way to take on at least a living interest. The *bright* pupils in the class, who so often become a problem to manage, can be given special work in this field which in due time can be presented by them to the class as a body, and they can be rewarded for this special work by receiving extra credit where such a system is maintained in the school, or, through the co-operation of the English Department, by these papers being submitted as part of the required work in English.

These papers can also be made to serve another useful purpose in schools where a mathematical club is being fostered by the department, first in their contribution to the variety of the program which is a matter of vital importance, if the success of the club is to be assured, and again in opening to the pupil an avenue to active participation in the club without the necessity of additional work in preparing his contribution. Too often places on such programs are rejected on the grounds of lack of time to prepare.

In order to secure and maintain the desired interest, some authors of textbooks, as Professor Miller, of the University of Illinois, points out, have gone so far in their historical notes as to sacrifice much of the accuracy of the historical information. Stories and incidents are given which are easily in the realm of the improbable. Pictures are shown purporting to be the likeness of certain characters of history who lived centuries before the art of photography was developed. In the cases of the ancients even the drawings are imaginative. Such as these, it seems to me, are distasteful to the student and lover of history, and are an influence calculated to lower the dignity of that science. Such fictitious things should, therefore, be omitted unless it be specifically stated that they are merely a matter of tradition.

Again, the history of mathematics brings home to the pupil the realization that not he alone has had to labor hard and long to get a reasonable mastery of the subject, but that many of the simple problems and ideas of the present lay unsolved and unorganized for centuries while many of the brightest minds worked over the very fields from which they were later developed.

History should certainly be a means of revealing to the pupil that mathematics is not merely an arbitrary assignment to the high school curriculum with a main purpose of adding difficulty to his tasks there, but that it forms the fundamental working basis of many of the other sciences and professions, which fact

alone may win him to a further study of the subject in his earlier years and, in turn, prevent a serious embarrassment later when he comes to the point of choosing a life profession.

Then to the pupil who early finds delight in mathematical accomplishment, history reveals the reward that civilization has given and is giving to the man of research.

The objections offered to this plan of correlation are so few and of so little consequence that only a mention of them is necessary—the answers being quite obvious.

They are as follows:

(1). High school pupils do not need a comprehensive grasp of the history of the subject.

(2). There is no practical application of the history of mathematics.

(3). The high school courses are often too crowded to justify time spent on unnecessary applications.

ATTITUDE OF MATHEMATICS TEACHERS TO USE OF HISTORY.

As relating to the attitude of the teaching profession in general toward the plan of correlation I shall endeavor to compare the attitude of 30 years ago with that of the present day.

In 1890, the Bureau of Education of the United States submitted a list of questions to 168 of the most widely known universities and colleges of the United States, and among this list were the two following: "Is any attention given to the history of mathematics?" and "Does it make the subject matter more interesting?" Only recently in a canvass of 55 college and high school teachers of mathematics these questions were asked:

1. Have you ever pursued a systematic course of study in the "History of Mathematics"?
2. Do you, as an educator, think that the "historical phase" should be emphasized in the teaching of high school algebra and geometry?
3. In your own experience as a teacher of these subjects, or as a supervisor, have you ever introduced the historical element in a systematic way? If so, which, if any, of the following methods A, B, C, D, E, F, did you use with best success?
4. Which, if any, of these methods would you recommend as best suited to the needs and demands of the high school age; and therefore best adapted for introduction into the high school texts and teaching?

Methods;

A. Notes or short biographical sketches scattered through the text adjacent to the topics treated.

B. A short historical sketch, somewhat connected, at the beginning, or end, of each chapter.

C. At the beginning or end of the book, a more extended and exhaustive discussion of the history of that particular branch.

D. A school library containing some historical books by the best authorities to which assignments can be made to pupils as desired, for investigation and class reports.

E. Foot-note references throughout the text to the page and article of such books as are mentioned in D. Class reports if desired.

F. (Supposing the teacher to be thoroughly conversant in the history of the subject taught.)
The teacher to give the historical facts, figures, stories, etc., at the very time the abstract work to which they pertain is being discussed in class.

Comparing the answers to the two questionnaires, we get the following results:

Year	Question	Yes	Only incidentally	No
1890	Is any attention given to History of M.	30%	44%	26%
1921	To a similiar question	48%	15%	37%

Of the 37% who gave no attention to history in their teaching in 1921, 70% have either pursued no regular course themselves in the history of the subject, or else have done only a small amount of private reading. This fact, it seems to me, is highly significant in the light of the last answer where 52% are giving either no encouragement at all to the historical setting of the subject taught, or else are giving it in only a limited way; whereas in the next statement we find that of this same group of teachers who were using no history in 1921, 89% of them recommend that it *ought to be done.*

	Have had formal history course	Not had formal course
Of those not using history in 1921	30%	70%

	Recommend use of history in teaching
Of those having had formal history course	100%
Of those not having had formal history course	94%
Of those not using history in teaching in 1921	89%

Furthermore, from the canvass of 1890 we find that of those answering the question, "Does it make the subject more interesting?" 95% gave the answer, "Yes, it does, most decidedly," while the remaining 5% were in some doubt about the matter and were even inclined to say "yes."

The canvass of 1921 shows that of those answering the similar question, "Do you, as an educator, believe the historical phase should be emphasized in teaching of high school mathematics?" 86% answered "Yes" emphatically, 11% say "In an incidental way," and 3% give the answer "No."

Question	Year	Yes	Doubt	Only incidentally	No
Does it make the subject more interesting?.........	1890	95%	5%		
Should historical element be emphasized, etc.?....	1921	86%		11%	3%

The only logical conclusion that can be drawn is that our teachers of secondary mathematics are not equipping themselves sufficiently in this field which they themselves agree is an important one.

Methods of Using History in Teaching.

Of the answers to the fourth question of the 1921 canvass which asked for a recommendation of the method best suited to the presentation of the history of mathematics in high school classes, there seems to be much difference of opinion, and in many cases combinations of two, three, and sometimes even four methods were given.

Of the methods mentioned singly as the best suited, A stands first with nearly as many supporters as all other methods combined; F ranks second with a score one-half as much as A; D comes third, with the others following in the order E, B, C.

When all the answers are considered, the method most frequently mentioned as desirable and practicable is F with a coefficient of 30; A second with a coefficient 27; D third, coefficient 20; B and E fourth, coefficient 9; C last, coefficient 5.

	Method	Rank	Relative Value
Recommended Methods of Introducing History	F	1st	30
	A	2nd	27
	D	3rd	20
	B & E	4th	9
	C	5th	5

Again the consensus of opinion in centering on F which presupposes that the teacher is conversant in the history of the science, points to the fact that we as teachers of mathematics, must not longer neglect this important phase of our preparation.

So, in briefly summing up the results of this investigation, it should be said that superintendents and principals of high schools ought to insist that their teachers of mathematics should not overlook this part of their preparation in connection with their other professional studies. And we might be reminded that a well-rounded course of instruction of this character is within reach of every teacher in the United States, if not through his own local college or university, then through the correspondence-study department of the University of Chicago.

Also one is reminded that if he belongs to the group who do not believe it practicable or profitable to make use of history in teaching, either his convictions are unsound and need reorganizing, or else 97%, apparently, of our teaching personnel are misinstructed and are laboring under false educational principles.

WORTH WHILE WORK WITH ALGEBRA FAILURES.

By Helen I. Westley,

Olean High School, Olean, N. Y.

"Wm. G. S——, son of Charles S——, ex-postmaster, graduated with high honors from the University of Dentistry of Buffalo." This item cut from a small town news letter published in the local paper brought back to my mind a very vivid picture of my first review algebra class. It brought to my mind one of the members, a lanky boy of sixteen with twinkling blue eyes, who had failed in algebra so many times that he took his failure as a matter of course. Interested in fishing and trapping, he managed to be absent quite often, and finally, a few weeks before the state examinations were due, he decided to "quit school" altogether. However, in the review class, he had been "exposed" to much algebra theory and had taken many written lessons, the results of some of which had led him to look upon the subject with a little less disfavor.

Regent's week in a small town contributes its quota to local gossip. The boys and girls everywhere discuss their hopes and fears. It was even so that year—and William could not resist wanting to have a share in the excitement. He asked to be allowed to try algebra, was admitted to the examination, and passed! That was in 1916. Since then there have been other

Williams and Kenneths and Marys who have found algebra was not impossible in a review or repeat class. They may not all be graduated from college with high honors; they may not be graduated from college at all. But some of them will complete their course in high school who otherwise would have become discouraged and dropped by the way. All of them will have more confidence in themselves and will be of more use in the world for having wiped out the failure that stood against them in the first year of the high school course. This is the opportunity which the review class in algebra affords. Some years, I have not been permitted to organize such groups. However, in many schools throughout the country there is a real need for these special classes.

In the summer time, I have my garden. In it, I have some early and some late sweet corn. But I do not plant here and there a hill of the latter in my patch of early corn. Neither do I neglect to care for the late corn once planted, even though I know it will not mature in time to make a brilliant showing at the fair. And so with repeat algebra classes. Seldom do they make a brilliant showing, yet certainly they are worth while. Then let us organize them.

Once organized, the real work has just begun, for the material, old to them, must be presented in a simple, new, and attractive way. This is not attempting the impossible although the opening weeks are sure to prove discouraging. The pupils who fail do not belong to one but to several different types. One does not want to think of them as types at all, but as individual boys and girls who must be taught to face their failures squarely, to analyze the causes, and to do their best at all times, realizing that success is the result of intelligent, persistent, hard work. As with the pupils, so with the teacher of a repeat class. She must work hard. She must be persistent. She must show intelligence in selecting and discarding methods, dealing with human nature, and facing her failures and successes sanely. Above all, she must believe that work with algebra failures is truly worth while.

To help pupils to face their failure and to analyze the causes, I ask each at the beginning of the course to write on a slip of paper his name, age, and the number of weeks he has had instruction in algebra, and what he believes was the reason for his failure. This information, which I keep for ready reference proves useful as well as entertaining. Last year, I found

several had had instruction 120 weeks, and some even laid claim to 140! The reasons given for failure were various. A few did not understand fractional equations; others, written problems. One girl maintained that her first term had been spent under a poor teacher, while several of the boys admitted quite frankly that they had not studied enough. Many seemed never to have given the matter of failure a thought, stating simply that they did not know!

Such a blank is useful in that it starts each boy and girl thinking—and some of them—working at once. The time statement is itself a challenge to both teacher and pupil. As to the reasons for failure, I believe a conference with the teacher at the end of the first month would supply much light on the subject to those who seem in doubt. Inaccuracy of thought and work, lack of desire to think and work independently, reluctance to check results where the correct answers are known, and the general belief that a review class should be a lecture rather than a laboratory course, all these trials characterize the opening weeks. Methods for making the crooked road straight must vary with the size and personnel of the class, the size and seating arrangement of the class room, and I was about to say the size and personality of the class teacher.

In a high school of from one to two hundred enrollment, the repeating division would number probably between eight and eighteen. Should the class be made up of "plodders" for the most part, then regular assignments from the text with frequent written reviews may be used. If the weekly averages are graphed in colored chalk on the board, with the names corresponding to the various colors beneath the chart, a friendly rivalry may be inspired. Particularly is this true if no grades below sixty are graphed. More frequently than not the review class has as many "live wires" as "plodders," and occasionally the former are in the majority. When such is the case, the teacher should be prepared to have her patience and her ingenuity taxed to the limit each day. I have found it best to abandon textbook work for such classes, and most outside written assignments in favor of the written test for four successive days followed by an explanation day on the fifth. Again, weekly averages may be graphed. It helps to equalize the differences which in turn results in keener rivalry if an occasional "bargain day" occurs when extra credit is given for extra problems.

In larger schools where the divisions number from twenty to

thirty-five, the daily written lesson plan, and blackboard graph is impracticable. If the class room is crowded, many excellent interest-getting plans have to be abandoned. Under such conditions, I depend upon a variety in class procedure to help stimulate interest. I give a daily assignment, written lessons as frequently as I can handle the papers, and use the blackboards rather sparingly. My aim is to have all the pupils functioning algebraically all of the class period. Cards, each one numbered, and each bearing a different exercise of the type being reviewed at the time, accomplishes this when other devices fail. The game—for we call it playing a game—is to see who can work the largest number correctly in a given time. Considerable interest results, if it is known previously that the record of each person will be posted on the blackboard, with honorable mention for each one making a perfect score. The work for the teacher may be lessened if the answers correspond in some way to the card number. For example, in the set for simplifying and adding radicals, Card No. 47 may have for its answer $4\sqrt{7}$, while Card No. 9 may read $2\sqrt{18}-4+\sqrt{32}-10\sqrt{2}+13$. A set of one hundred cards is sufficient for a class of twenty-five for a thirty-minute drill if a satisfactory method of exchange has been worked out previously.

I will not proceed further in the discussion of ways and means. Any whom I have convinced of the desirability of classes for the June failures, if indeed, I have convinced any, will become enthusasitic over the plan upon giving it a fair trial. And the Williams and Kenneths and Marys who are saved thereby for higher education and greater usefulness may rise up to call us blessed. If they forget to, we who have been some time in the profession shall not be too greatly surprised or disappointed. At least we will have done our part in helping to remove the bugbear from junior mathematics, and shall have felt the satisfaction which comes with worth-while work.

INCREASE IN PIG IRON.

The production of pig iron, excluding ferroalloys, as reported to the Geological Survey, was 36, 242,748 gross tons, an increase of 19 per cent as compared with 1919. The quantity of pig iron, exclusive of ferroalloys, shipped or used in 1920, according to producers' reports, amounted to 35,710,227 gross tons, valued f. o. b. at the furnaces at $1,140,904,096, an increase of 19 per cent in quantity and of 47 per cent in value as compared with 1919. The average price per ton at furnaces in 1920, according to these figures, was $31.95, as compared with $25.75 in 1919.

THE APPLICATION OF THE PRINCIPLES OF EFFICIENCY TO THE TEACHING OF CHEMISTRY.

By J. Norman Taylor,
George Washington University.

The principles of efficiency find immediate and valuable application in all walks of life. This short paper will be confined to an outline of them, touching upon each one as applied to chemistry teaching, but not attempting a detailed discussion.

In reading the "Study of Engineering Education" by Dr. Charles Riborg Mann[1], one is struck by his statement that "Efficiency in the mastery of materials without humane intelligence to guide and control it is now recognized in all civilized countries as a curse."

Complete and true efficiency is material only in its application and is fundamentally ethical or moral in its nature. Individuals, or groups of individuals, who do not realize and demonstrate the truth that it is servant and not master are attempting to operate against natural laws. That efficiency in the mastery of materials must be guided by common sense and morality, and that mechanical efficiency must be subordinated, offers an opportunity, says Dr. Mann, to the humanistic studies. "This has already been perceived at a number of schools, and many efforts are being made to alter the content of the courses in English, in history, and in economics to meet the obvious need."

Although efficiency cannot be defined very accurately because of its many phases and manifestations, the definition given by Harrington Emerson is comprehensive and satisfying. Personal efficiency, he states to be "mental and physical ability to find and take the best, easiest and quickest ways to the desirable things of life."

Can not we apply to the development of intelligence and to the efforts of the teacher the methods of the industrial and business world which have contributed so largely to its success?

Sir Robert Blair, in his opening address[2] as President of Section L (Educational Science) delivered at the Cardiff meeting of the British Association for the Advancement of Science, made clear that a valuable aid to education is the inculcation of the teaching profession with the scientific spirit. "Matter taught and teaching methods are no longer exclusively determined by

[1]Carnegie Foundation for the Advancement of Teaching, Bulletin 11, 1918.
[2]Nature, November 4, 1920, P. 323.

mere tradition or mere opinion." "Education as a science should be something more than mere applied psychology. It must be built up not of the speculations of theorists, or from the deductions of psychologists, but by direct, definite *ad hoc* inquiries concentrated upon the problems of the class room by teachers themselves."

No attempt will be made here to detail the subject matter of chemistry courses or its method of presentation. It will be sufficient to outline the principles which have been set forth by Mr. Emerson,[3] and under each of these to mention its application to the teaching of chemistry, together with some practical suggestions as to its application.

The principles, which may be set down as thirteen in number according to Mr. Emerson's latest classification, are divided into seven practical and six ethical ones. It will be seen that they are independent and at the same time interdependent:

The Seven Practical Principles:

1. **Records**
2. **Plans**
3. **Schedules**
4. **Despatching**
5. **Standardized Conditions**
6. **Standardized Operations**
7. **Written Standard Practice Instructions**

The Six Ethical Principles:

1. **Ideals**
2. **Common Sense**
3. **Competent Counsel**
4. **Discipline**
5. **Fair Deal**
6. **Efficiency Reward**

In the application of any one, or all, of these principles it will be necessary at the outset to establish standards. In order to carry on any part of the teaching of chemistry and in fact all parts, we make use of standards, and about the first thing that is necessary to be done is to set a standard for ourselves and for the pupils regarding how to study. For the individual teacher this may be accomplished much more easily than for the pupils. It is only after a large number of trials that standards can be established which will apply to a large group of individuals.

Records.

In order to establish standards which will be just, "recourse must be made to records and they must be immediate, reliable, adequate and permanent." Convenient types of record cards

[3]Emerson, Harrington. "The Twelve Principles of Efficiency." 5th Ed., Engineering Magazine Co., New York, 1917.

are those put out by the Rand Company and by the Library Bureau. Paste board transfer cases may be used in place of the more expensive cabinets. Cheap paper stock may be cut up and used in place of heavy card stock.

Records are indispensible in determining amounts of chemicals and apparatus on hand in the laboratory as well as in the selection of the best place from which to order. Records measure progress and show its direction, and as examples we have the student's note book and the instructor's record of quizzes. The quiz record, however, may not be only of value in determining grades but it may also "warn of wrong methods, unwise procedure, and inefficient operations." It also grades the teacher's efficiency. Records are of great value as a basis for future work.

Plans.

Records, therefore, are useful in making plans—one of the most important of the thirteen principles. Through their consultation the instructor is enabled to plan the scope and order of the work for the year, to find out how best to allot his supply of time for laboratory and lecture work, and to plan what detail to assign to his assistants.

In planning for the best method of presentation of the subject, he may find, upon consulting his records of quizzes and of recitations, and upon comparing them with the grades evidenced from examination of the laboratory note books, that the best method is through the laboratory. Or, he may find that for a particular class the lecture table demonstration method or the project method is the most efficient. Or, that the lecture-demonstration-conversation method excells all of these. If he keeps a record of the ratings in "chemistry exercises" or study questions worked out by the students and of the grades for special topics and reports, he may find these to be excellent supplementary aids in teaching.

Instruction by the informal recitation method has been successfully applied by Professor Karsner[4] to medical education. The method will undoubtedly prove applicable as a means of teaching some parts of chemistry.

Through consulting records the instructor can plan for equipment. Knowing through his records, the amount of time supply available, he can plan for time in which to study and to keep abreast of the developments in the science. He can plan for

[4]Karsner, Howard T., "'Progressive Education' in the Teaching of Pathology," Science, July 29, 1921, pp. 81-84.

recreation to maintain his health and permit of the greatest force and usefulness.

SCHEDULES.

Having now made plans, schedules must be employed to assist in the execution of them, and again we go back to a study of the standards which we have established. These, of course, were obtained from a study of records made over a period of time.

Schedules save time and energy, add interest to work, and are a great aid to concentration. Schedules, properly worked out, assure us of an adequate time supply for each task. The late Professor William James, in his "Talks to Teachers," says:

"Your intense, convulsive worker breaks down and has bad moods so often that you never know where he may be when you most need his help. He may be having one of his 'bad days.' We say that so many of our fellow-countrymen collapse, and have to be sent abroad to rest their nerves because they work so hard. I suspect that this is an immense mistake. I suspect that neither the nature nor the amount of our work is accountable for the frequency and severity of our break-downs but that their cause lies rather in those absurd feelings of hurry and having no time, in that breathlessness and tension, that anxiety of feature and that solicitude of results, that lack of inner harmony and ease, in short, by which with us the work is apt to be accompanied, and from which a European who should do the same work would nine times out of ten be free. . . . It is your relaxed and easy worker, who is in no hurry, and quite thoughtless most of the while of consequences, who is your efficient worker; and tension and anxiety, and present and future, all mixed up together in one mind at once, are the surest drags upon steady progress and hindrances to our success."

In arranging a schedule for carrying out an experiment in the laboratory, or for a lecture illustrated by demonstrations, there will be listed the equipment necessary, both as to quantity and place and the standard time for the operation.

DESPATCHING.

It is not enough to establish standards, to plan, to write schedules. The things in question must be done and done at the proper time. In other words, the schedule must be despatched. A good rule for the laboratory and lecture room for both instructor and pupil is, "always begin on time and finish on time." If the schedule is maintained and each operation is despatched promptly, much waste of time will be prevented.

Ordering of supplies should be despatched in sufficient time for the goods to arrive before the beginning of the fall term. Despatching of the instructor's reading and studying will prevent the accumulation of too many books and periodicals and will greatly assist the instructor to keep up with the latest and best thoughts of his profession.

Aids in dispatching such as bells, gongs, or buzzers, index cards arranged for months and days (sometimes known as "ticklers"), interval clocks, alarm clocks, stop watches are valuable and should be freely used. All of these mechanical devices are, however, dependent upon mental training, as efficiency in despatching is essentially a mental quality.

Standardized Conditions.

When the conditions under which the instructor and pupils work have been standardized, the work will be carried on much more quickly and in an easier manner. Much less conscious mental effort is required where standardized conditions obtain. These include lighting, ventilation, maintaining a proper temperature, equipment, and library facilities. It may be of interest to some readers of this paper to note a description by the present writer of the Chemical Laboratory and Lecture Room at the Washington Y. M. C. A. which appeared in the Journal of Industrial and Engineering Chemistry for June, 1920.

Alphabetical or numerical seating of pupils saves time in taking attendance and helps in noting absences. Arrangement of chemicals alphabetically is an excellent procedure. A higher efficiency of assignment will be attained by the instructor and his time therefore be used to better advantage if minor details are assigned to some of the pupils. A pupil invariably feels complimented when appointed for the period as a laboratory assistant and takes a lively interest in getting out and putting away materials and in seeing that the other students keep things clean.

Standardized Operations.

It is impracticable to go very far in standardizing conditions without first standardizing the operations by which the conditions were brought about, and oftentimes we must first break away from tradition before we can properly get on a new and better basis. Standardized operations replace guesswork by accurate knowledge. They are orderly.

As an example applicable to chemistry teaching may be given the arrangement of apparatus in conducting experiments—the proper assembling and setting up of the parts so that they are

in "coordination." In demonstrating, it is well to arrange apparatus and chemicals in the order in which they are to be used and from left to right.

It will be found if students are instructed to note their laboratory experiments in a uniform manner—as for example (1) Object, (2) Apparatus and Materials, (3) Procedure, (4) Observations, (5) Conclusions or Results—that it will be much easier for the instructor to examine the note books. However, as the note book is the pupil's own record of what he does, the instructor's standards regarding acceptable forms of notation should be flexible. Diagrams accompanying procedure are desirable. Answers to specific questions should be included in the note book.

Professor Munroe's "Scheme for Chemical Recitations" is one deserving of special mention and the "Freas System" for distributing chemicals in the laboratory is helpful and easily installed. An economy in energy expended in the stockroom and in the accounting department is the ordering of laboratory supplies by multiples of ten.

Written Standard Practice Instructions.

The universal application of the seventh principle is familiar to everyone: school books, technical books, professional and trade journals, mottoes, slogans, recipes, legal forms, style rules and many more are in everyday use.

In connection with the teaching of chemistry—records, plans, schedules, and memoranda for dispatching have created a body of written standard practice instructions.

Perhaps the most notable example is the laboratory manual. The loose leaf system presents a number of favorable features. Included as a part of the loose leaf laboratory manual are sheets setting forth the general rules governing the laboratory; tables, such as the metric tables, the elements with their symbols and atomic weights, solubilities, water vapor pressure; first aid; and textbook references. The type of student in continuation schools, particularly those students attending the Washington Y. M. C. A. presents, on the average, those persons of more mature minds. Accordingly, the direction sheets have been prepared with the particular idea of setting forth, in an elementary way, the subject of chemistry in great measure by the laboratory method, and for a class of students more mature than the average high school pupil.

The textbook, another example of written standard practice

instructions, is next in value to the laboratory manual. Its proper function is to elucidate the experimental facts and to furnish information that is not accessible to the student by experiment. Of course, the laboratory work should be accompanied by recitations, discussions, and lectures with demonstrations. The experimental facts and common knowledge should be presented, not as isolated things, but to correlate and explain modern theory.

Special instruction sheets may be issued from time to time as occasion demands and may constitute a part of the laboratory manual. Professor Munroe's method of balancing equations should be in the hands of every chemistry student. Proficiency in working out stoichiometrical problems may be developed by the solution of practical problems submitted to the student at regular intervals. Energy and time may be conserved by enlisting the cooperation of the school office in the matter of multigraphing the sheets.

Some other examples of written standard practice instructions familiar to chemistry teachers are specifications for making, ordering and purchasing materials and equipment, graphs, charts of organization, slide rules, formulas for quick calculating, standard methods of analysis, and the various chemists' manuals and annuals.

Concluding the consideration of the seven practical principles we come to a survey of some of those which Mr. Emerson includes in the moral or ethical ones. In his classification he differentiates those which are mechanical in their applications from those which are basic or mental.

Ideals.

We are all aware of the value and dynamic worth of high ideals.

We are conscious of the futility of confused ideals. To quote Harrington Emerson, "the vessel that sails for no particular port reaches any port at all only by the rarest accident."

We recognize the waste of wrong or mistaken ideals. Material efficiency must be guided by something more than materialistic ideals. This truth was effectively set forth in the convocation address[5] by Dr. Charles Alexander Richmond, President of Union College, at the centennial celebration of George Washington University. In speaking of the unwise use of science, he said:

[5] Proceedings of The Centennial Celebration of George Washington University, February Nineteenth to Twenty-sixth, 1921, University Bulletin, Vol. XX, No. 1, March, 1921.

"We have had now something like fifty years of an education which has become more and more absorbed in studying and applying the powers and processes of physical nature. So far as it has applied to man it has been as an interesting and highly diversified animal, rather than as a spiritual being. When we count up our gains and losses we are often perplexed to know on which side the balance lies. Certain large promissory notes have not been made good. Many of our profits are paper profits and not a few of our securities have gone bad. She has promised us civilization, she has given us physical comfort; she has promised us emancipation, she has given us efficiency; she has promised us content, she has given us more discontent, by multiplying cravings which she does not and cannot satisfy. As for the promise of happiness, that note has certainly gone to protest. The fault is not with science, the fault is our own. We have been asking her to give us that which was not hers to give. * * * * It is a subject of Homeric mirth to see the use we make of our time, our energies, our genius, our resources. * * * * Never in the history of mankind has he been so utterly the slave of things. * * * * The underlying theory of it all, held, as I believe, quite unconsciously, is that the possession of money will emancipate from the bondage of work and enable us to live free and easy lives; and that this is the goal of human aspiration and the only happiness we can be sure of. * * * * To make such a theory the foundation of a system of education and to teach our children in the schools and the young men and women in our colleges that this is life, would be like injecting an insidious kind of poison into them, which would slowly corrupt the blood and in the end destroy all the finer impulses and ideals. * * * * My plea today is for the safeguarding of these higher values; a regard for the ultimate rather than the immediate."

In the younger student, ideals are sometimes held subconsciously. How many of us in sitting at the feet of our teacher have embodied our ideals in him! And some of us may have had an ideal born by a chance word or look or action on the part of our preceptor.

Too much emphasis cannot be laid upon the aims in the teaching of chemistry in high school or college. The following admirably formulated ones are particularly important:

1. To give an understanding of the significance and importance of chemistry in our national life. [5]

2. To develop those specific interests, habits, and abilities to which all science study should contribute.[6]
3. The necessity of awakening the minds of our pupils to the possibilities of achievement.[7]
4. The understanding and use of the scientific method of procedure.[6]
5. Acquisition of knowledge which serves as a basis of skills.[6]
6. To inculcate moral law and to emphasize universal order.
7. To at least, "exercise the pupil in applying standard methods to new problems, with the possibilities that he may learn later to use the same methods in life, and so become a rational and useful citizen."

Attention is directed to the apparent necessity for high school chemistry, in order to be vocational, to include a three year course. College courses in chemistry should be coordinated with the preparatory school courses so that students upon entering college can take up the study of chemistry without repetition of their previous work.

COMPETENT COUNSEL.

Contact with others who are doing the same kind of work, and exchange of ideas is indispensable in any line of work. This is particularly true where the teaching of a growing and advancing science is concerned.

Membership in the American Chemical Society, Chemistry Teachers' Associations, the American Association for the Advancement of Science and other organizations of similar character, attendance upon meetings, conventions, and expositions; and keeping up with the times by subscribing to and reading the current chemical literature are excellent examples of competent counsel.

The school library is an important example of competent counsel. Extensive lists of books suitable for a chemistry library have been issued by the New England Association of Chemistry Teachers and by the Chemistry Teachers' Club of New York City. The American Chemical Society has in preparation reading courses on Chemistry. Subscription to some good periodical on business methods will undoubtedly be advantageous to the chemistry teacher.

A systematically arranged collection of substances that are of interest to students of chemistry is of great help in teaching, as are also occasional trips to manufacturing establishments and to industrial museums and those illustrating natural history.

A departure in museums, of particular interest to the chemical

[6]Report of the Commission on the Reorganization of Secondary Education, Published in "Treasure Hunting of Today and Chemistry in Our Schools." Bureau of Education, Department of the Interior, Washington.

[7]Resolutions of the Chemistry Section of the Central Association of Science and Mathematics Teachers. Published in THIS JOURNAL, March, 1921.

profession, is the Museum of Chemical Types established by the Smithsonian Institution, to fulfil a bequest of the late Morris Loeb. The museum will include original specimens of all new chemical substances and make them available to research workers for reference purposes.

Other examples of competent counsel are bulletins of the Government Departments, manufacturers' catalogues, Lefax, and chemical dictionaries[8] and encyclopedias.

COMMON SENSE.

Almost indefinable, this quality is one of the greatest value to the teacher.

It is a guide in the choice of ideals, major, minor, and lateral.

It is a guide in the choice of standards.

It is the guide to good judgment—sound, instinctive reasoning.

It is the best guide to all our actions and decisions in the classroom and out.

It can be developed.

Its very essence is *mental alertness.*

The fair deal, discipline and the efficiency reward hardly need any comment. The essential elements underlying the principle of common sense apply to these also. In order to be of the greatest service the chemistry teacher must not only require a fair deal from others but he must be fair to himself. Too much emphasis cannot be placed upon the value of health culture. Sufficient sleep, proper food with plenty of vitamines, and sufficient recreation are prime considerations.

By all means cultivate a sense of humor. It is a saving grace. "The teacher who can appreciate the humor of a mistranslation, of a ludicrous mistake, of a ready reply, of a disciplinary situation that is at once serious and comic, has a power that will destroy the bitterness of many a heartache and save the day in many a disciplinary crisis. If he is himself something of a humorist, so much the better.[9]"

Assiduity in the application of the principles indicated above—always keeping in mind the ideals which we have formulated and allowing common sense to guide us—will bring us our reward: better chemistry teaching; more leisure for self improvement; a greater enjoyment of work and play; and, in larger measure, the ability to both aspire and inspire.

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[8]A Dictionary of Chemical Terms by Couch (D. Van Nostrand & Co., New York) should be available to every chemistry teacher.
[9]Brown, John Franklin, "The American High School," The Macmillan Co., New York, 1914.

TWO CORRECTIONS FOR KATER'S PENDULUM.

By John B Kremer,
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One type of Kater's reversible pendulum, which is often used in the laboratory to determine the local value of the force of gravity, consists of a long steel bar, of circular or rectangular cross-section, to which the movable weights are clamped. At some distance from either end, the bar is provided with knife-edges, also made of steel.

In order to obtain good results with such a pendulum, the writer found it necessary to make two corrections, which are not usually mentioned in laboratory manuals giving directions for this experiment.

(1)

One of these corrections refers to the period of the pendulum. In our northern latitudes, a long steel bar becomes sufficiently magnetized, if held in a vertical position, to deflect a compass needle placed some distance east or west from the end of the bar, as is well known. A long steel pendulum, therefore, will be swinging under the influence of two forces, namely gravity and the earth's magnetic field. The observed period of the pendulum must therefore be corrected for this magnetic force. It may be noted, however, that, except in rare cases, when the bar has become permanently magnetized, the influence of the earth's magnetic field will not affect the first, but only the second or third decimal place in the final result.

From the observed period, corrected, of course, for amplitude, clock error, etc., the true period of the pendulum for gravity alone, can be found as follows.

Let t' represent the time for one half swing of the pendulum if gravity alone had been acting on it, and t'' the time actually observed. Then, from the well known formulae for the period of compound pendulum kept in motion by the force of gravity, and the period of a magnet oscillating in a magnetic field, we get the following proportion:

$$\frac{t'}{t''} = \frac{\pi\sqrt{I/Mgh}}{\pi\sqrt{I/Mgh+mlH}}$$

and dividing we get,

$$t' = (\sqrt{1+mlH/Mgh})\,t''$$

where:

M = mass of pendulum in grams.

I = moment of inertia of the pendulum about that knife-edge for which t is to be found.

h = distance between the center of mass and the knife-edge.

m = the number of unit poles induced in the bar.

l = distance between the poles.

H = vertical component of the earth's magnetic field.

If the local value of g is not already fairly well known, it can be first determined, with sufficient accuracy for the present purpose, from the formula for Kater's pendulum, without the correction for magnetism.

Regarding the determination of m & H, however, it is important to remember that the pole strength of the pendulum is different in a vertical position from that in any other position, and that H may have different values in different parts of the laboratory. Consequently, these two quantities must be determined for the position and the place in which the pendulum was swinging. The vertical component of the earth's field only, is needed for substitution in the formula, but the horizontal component must also be known in order to find m, as we shall see. Both these quantities may be found by any approved method. But m can not be found by the usual method, since it must be found with the bar in a vertical position. The following procedure may be adopted.

Place a compass needle, a short distance r east or west from the lower end of the pendulum and note the position of the needle. Then remove the pendulum far enough to allow the needle to swing into the magnetic meridian. The deflection of the needle thus produced may be considered as entirely due the pole strength of the lower end of the bar, since the horizontal component of the upper pole, when r is small, is practically zero.

The field strength of the lower pole at the distance r can then be calculated from the formula:

$$H'/H = \tan a$$

where H' is the field strength of the pole; H the horizontal component of the earth's field, and a, the angle of deflection.

Knowing the field strength at a given distance r from the pole, m, the number of unit poles in the bar can be obtained from the formula

$$m = (4\pi r^2 H^1)/4\pi = r^2 H^1$$

Since the pendulum is a very long magnet, 1, the distance between the poles may be taken as equal to the length of the bar.

If the pendulum shows a different pole strength when turned

end for end, as is often the case, this pole, too, must be determined.

(2)

Another source of error with the common type of Kater's pendulum lies in the knife-edges. Steel knife-edges soon become blunt or rounded, with the result that the pendulum merely rocks to and fro on the knife-edge and actually rotates about a point within the knife-edge. The axis of rotation, therefore, measured from the center of mass of pendulum, lies some distance farther than the edge of the knife-edge in contact with the support. To measure this distance, or the radius of curvature, an impression of the knife-edge can be made by pressing a piece of wax or lead against the point of the knife-edge. This impression can then be placed under a microscope so that a cross-section of the groove is seen in the field, and the radius of curvature can then be measured by means of the cross wires of a micrometer eye piece. As a help to estimate the radius of curvature, a very fine wire, with its end bent at a right angle, can be held in the groove so that a cross-section of both is seen at the same time in the microscope.

The radii of both knife edges thus found must be added to the distance between the knife-edges in order to find the distance between the axes of rotation which is needed in the formula.

USE OF THE INCANDESCENT LAMP IN STEREOPTICONS.

By C. E. Egeler,

Engineering Department, National Lamp Works of General Electric Co., Cleveland, Ohio.

Manufacturers have succeeded in developing stereopticon lanterns which are reliable, powerful, conveniently portable, and when adapted to the incandescent electric lamp, extremely simple in operation. Properly handled, these lanterns require little attention and give satisfaction extending over years of service. However, in the excellence of results obtained by different operators with the same lantern, a considerable variation is frequently apparent. This variation can usually be traced to a difference in the selection and use of the incandescent lamp.

Selection of Lamp.

It is a distinct advantage to be able to connect a stereopticon lantern to any standard lighting circuit and for this reason a lamp rated for 110, 115, or 120 volts is desirable. These lamps are regularly listed by the manufacturer in 250, 400, and 1,000 watt

sizes.[1] The 250-watt size is supplied in a round bulb measuring 3-¾ inches in diameter. In the higher wattages, a tubular shaped bulb is used which permits the filament to be placed close to the condenser lens where a relatively large proportion of the total light will strike the lens. With this bulb, blackening, which accompanies the evaporation of the filament in service, is confined very largely to the upper portion of the bulb where it does not seriously affect the useful light output.

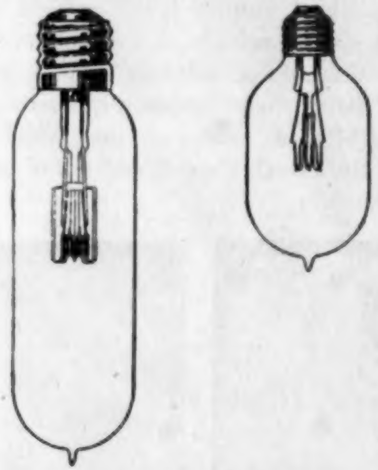

Fig. 1 - Typical Mazda Lamps for Stereopticon Service
400-watt and 1000-watt, 115-volt

The 250-watt lamp may be operated in any position except within 45 degrees of the vertical tip-down position; the tubular bulb lamps are designed for tip-up burning but may be burned at an angle within 25 degrees of the vertical position without materially affecting their performance. Additional data on these lamps are given in Table 1.

TABLE No. 1.

Data on 110, 115 and 120 Volt Mazda C Lamps for Stereopticon Service.

Watts	Approx. Lumens	Bulb	Bulb Diameter, Inches	Max. Over-all Length, Inches	Light Center Length, Inches	Base
250	4500	Round	3-¾	5-½	3	Med. Screw
400	8200	Tubular	2-½	5-½	3	Med. Screw
1000	24000	Tubular	2-½	9-½	4-¾	Mog. Screw

The light output of an incandescent lamp is considerably reduced when the voltage is lowered. Although the life is shorten-

[1]A 100-watt round-bulb lamp in this voltage class is also regularly listed but because of its low power its use is restricted to machines smaller than those suitable for general class-room work.

ed when the voltage is raised, it must be remembered that the voltage at the baseboard socket or fixture socket is usually appreciably lower than that at the service entrance. For machines which are used in fixed locations, the voltage at the socket should correspond to the rated voltage of the lamp. Where the machine is moved from place to place or from city to city, frequently involving the use of long extension cords, allowance must be made for this further voltage drop. For this service, it is usually advisable to employ lamps rated a few volts lower than the lighting circuit voltage, a 110-volt lamp for 115-volt service, a 115-volt lamp for 120-volt service, etc., or, better, to carry lamps of two voltage ratings. In this way, the lecturer is usually assured of clear, bright pictures which is of far more importance than the possible small additional expense of more frequent lamp renewals.

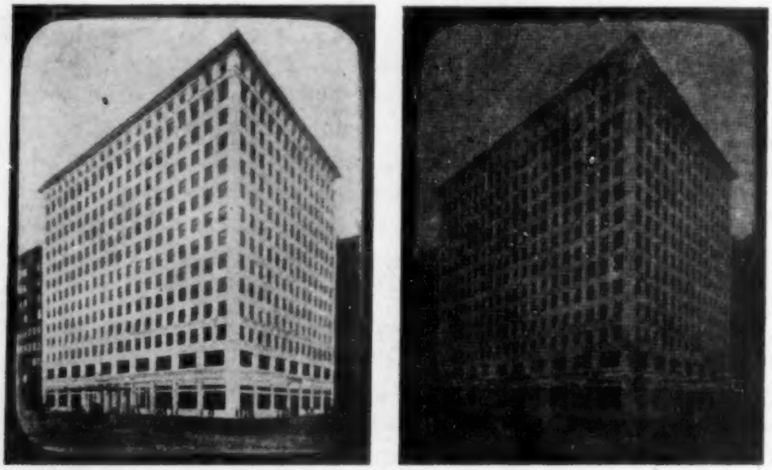

Fig. 2 - Effect of Size and Shape of Source on Projected Image. Photograph of the same slide projected by stereopticon lamp and regular lamp of equal wattage.

Where voltages of approximately 30 volts are available, as in laboratories or outlying districts where electricity is furnished from 28-32 volt farm-lighting plants, or where a transformer or rheostat can be conveniently employed to reduce the potential of standard lighting circuits to this lower value, the use of the lower voltage stereopticon lamps, listed in Tables 2 and 3, is often preferable. These are made in the 300, 600, and 900 watt sizes. Because these lamps are low-voltage high-current lamps, the filaments can be kept small. This is a distinct advantage

because, other things being equal, the optical system of a lantern can utilize the light from a moderately small source area to better advantage than that from a large source area. These lamps are supplied in the tubular bulb only and should never be lighted except when in a vertical tip-up position or within 25 degrees of this position.

TABLE No. 2.

Data on 28-32 Volt Mazda C Lamps for Stereopticon Service.

Watts	Approx. Lumens	Bulb	Bulb Diameter, Inches	Max. Over-all Length, Inches	Light Center Length,[1] Inches	Base
300	6800	Tubular	2	5-½	3	Med. Screw

TABLE No. 3.

Data on 20 and 30 Ampere Mazda C Lamps for Stereopticon Service

Am.	Approx. Watts	Approx. Lumens	Bulb	Bulb Diameter, Inches	Max. Over-all Length, Inches	Light Center Length,[1] Inches	Base
20	600	15000	Tubular	2-½	9-½	4-¾	Mog. Screw
30	900	24000	Tubular	2-½	9-½	4-¾	Mog. Screw

[1]The light-center length is the distance from the center of the filament to the end contact point of the screw base.

The filaments of the 600 and 900 watt lamps are designed for an exact value of current rather than voltage and it is essential that the equipment provide a means for holding the current at exactly the rated value.

Table 4 shows the projection distances and picture sizes to which the several Mazda lamps discussed above are adapted. The data of this table apply to the projection of average density slides to white-cloth screens, which have been commonly used, especially with portable equipments. As is pointed out later on, in many cases a screen should be used having higher brightness characteristics, in which case longer projection distances and, if desirable, larger pictures, can be employed than are specified for the lamps listed.

USE OF SPHERICAL MIRROR.

Only light which reaches the condenser lens from such directions that the rays can be refracted by the condenser into a beam which travels through the slide to the objective lens is useful light. It follows that the source should direct as much light as possible toward the condenser and should not be so large that the beam emerging from the condenser, which converges to an image of the source at its smallest diameter, cannot pass through the

objective lens to the screen. The filament of an incandescent lamp emits light in all directions and even where designed to throw light strongly in the direction of the condenser it will throw an equal volume in an exactly opposite direction. In order to utilize this light, a spherical mirror is placed behind the lamp which reflects the light striking it back between the filament coils and on to the condenser. By the proper use of this spherical mirror, the light on the screen may be increased by more than 50%.

TABLE NO. 4.

Lamp Sizes for Various Projection Distances and Picture Sizes.

The general limitations given are for average density slides, projected to good quality white cloth screens, except as otherwise noted.

Projection Distance Feet	Largest Picture Width—Feet	Watts	Lamps Volts	Amperes
25 and below	8	250	110–120	
25-35	12	400	110–120	....
	12	300	28–32	
35-50	10	400	110–120	....
	10	300	28–32	....
50-75	15	600	....	20
	16	1000	110–120	....
75-100	16	600[3]	....	20
	16	1000[3]	110–120	....
	18	900	....	30

ADJUSTMENT OF THE LAMP AND MIRROR.

Although the method of adjusting the lamp and mirror is different in different types of machines, the principles are the same in every case. The position of the machine is first decided upon by lighting the lamp, bringing a slide into focus on the screen, and moving the lantern back and forth until the picture is of suitable size; the slide is then removed. This fixes the position of the objective lens with respect to the condenser and slide. If the lamp is of the type in which the filament coils lie in a single plane, this plane should be parallel to the condenser. The lamp is then inspected to see that its position is such that the beam passes through the objective lens. After this adjustment has been made, the lamp is moved backward and forward, keeping the center of the filament in the optical axis, and the changes in screen illumination noted. If the filament is well in front of the proper position, the field will appear irregularly mottled with blue-gray patches, or "ghosts" as they are called;

[3]Use reflecting type metallized surface screen. See text screen for data.

if well behind, the field will be lined with concentric rings of a reddish-yellow color. When the source is properly centered, both horizontally and vertically, these irregularities will disappear.

The mirror is next placed in position behind the lamp with its center in the optical axis, and is moved toward and away from the lamp until the best possible field is obtained on the screen. The edge of the mirror should then be thrown out of parallel with the condenser lens by a small fraction of an inch, the screen being watched meanwhile to note the effect. If an improvement is apparent, the mirror should be left in this position. The purpose of this last adjustment is to make sure that a maximum amount of the reflected light passes between the filament coils to the condenser lens.

When the best possible field has been obtained, and all parts locked in position, the machine is ready for operation. As long as the distance between the screen and the machine is kept about the same when the machine is moved about from place to place, the lamp and mirror adjustment need not be changed.

Adapting the Screen to the Purpose.

Although the portable screens commonly employed are of the white cloth type which is easily rolled and carried, this type is not usually the most efficient which can be employed. The white cloth screen diffuses light in all directions, making it very suitable for wide rooms but the maximum brightness which can be obtained is not nearly so great as that which can be obtained with a screen finished with a metallic coating such as aluminum or other similar special paint. Compared to the diffusing types, these metallized surfaces reflect as high as over three times the light in directions near a normal to the screen, with materially lesser and rapidly decreasing values at angles greater than from 15 to 20 degrees. These screens should therefore be used when the greater part of the audience can sit where the picture will not be viewed at angles of over about 20 degrees with the normal.

ERRATUM.

The article on Teaching Valency on page 772 of the November number should have been credited to Lula Gaines Winston, Meredith College, Raleigh, N. C.

THE TEACHING OF PLACE GEOGRAPHY.

By Douglas C. Ridgley,
Illinois State Normal University, Normal, Illinois.

Importance of Knowing Places.

The reader of current news is confronted at every turn with names of places familiar and unfamiliar. The pages of a single issue of a metropolitan newspaper may contain the names of hundreds of places. The reader gets more from his reading of news items if he is able to visualize accurately the places mentioned in their map relations and in their actual earth positions with reference to his home and to each other.

It is the business of the teacher of geography in the elementary school to make sure that pupils develop the ability to locate places by use of maps of the textbook, atlas, and wall maps. The teaching of mere location as such is not vital geography, but to omit definite instruction in the location of places through interesting and valuable exercises is to fail in developing properly a geographic sense of place relationships. The pupil should leave the geography work of the elementary school capable of locating definitely and accurately a goodly number of important geographical places in each continent, a larger number in United States and Europe than in other regions. He should be able to locate all unfamiliar places named in current news fairly well with reference to some important place learned in his school work. He should have developed the ability and the desire to use an atlas intelligently in finding on the map the places whose location he wishes to know.

A knowledge of place is as essential in the study of geography as a knowledge of the multiplication table in the teaching of arithmetic. A bare multiplication table and a mere list of places are both of little value when standing alone. In the hands of a skillful teacher both may be made alive by enabling the pupils to test their own ability to do things not set down in books.

If the place map is used merely to identify and to name indicated places, the exercise becomes as dry and as meaningless as a study of the bare figures of the multiplication table. If, however, the places are made to appear in their geographic significance, the place map may be as useful in the study of geography as the multiplication table is in mathematical calculations in everyday life.

Our Method of Teaching Place Names.

The mere naming of places on a map does not go far in the

teaching of place geography. Unless the name of the place is associated with worth-while information concerning the place, there is little need or value in teaching the name at all. If a close relationship is emphasized among the name, location, and geographic facts of a place the study becomes valuable. By strong and definite association, the name, the location and the importance of the place are all learned more effectively than otherwise. In the teaching of geography through journey stories, industrial topics, or from a topical outline due emphasis should be given to the vigorous thinking of geographic relationships of places as the basis for remembering them distinctly and correctly.

Let us take for example the problem of teaching some 85 place names in South America. Let these 85 place names include: 13 coast features, 46 cities, 20 rivers, 1 lake and 5 mountains.

The method described below was used with normal school students but can be followed with slight modification in the upper grades.

The members of the class were assigned the task of planning a journey from their home to South America with travels in the continent to reach or pass near each of the 85 places. The 85 names were written in the order in which the places were to be visited. Some time was used in searching the textbook, geographical readers, and other reference material for two or three important geographic facts about each place. These facts were indicated in brief notes under each of the 85 names. Following this preliminary work three lessons were devoted to the writing of an essay describing briefly the route followed from home to South America, the journey through the continent, and the return journey. These essays were read in class from day to day as the work was being developed.

The results can best be shown by quotations from one of the essays.

"Leaving Normal, Illinois, on the Illinois Central railroad, we reached New Orleans, Louisiana. Here we took a steamer for South America. We sailed for a hundred miles down the Mississippi, then across the Gulf of Mexico, through the Yucatan Channel into the Caribbean Sea. The Caribbean is a warm sea of indescribable blue upon which strange plants float and through which strange fish swim. We landed at Barranquilla, an important seaport on the coast of Columbia on the main branch of the

Magdalena River. The white inhabitants of Columbia are of Spanish descent and speak the Spanish language.

"We went from here to Ecuador, a country which stretches across the Andes. Ecuador may be divided into three parts: the lowlands along the Pacific; the mountains and the plateaus in the center; and the lowlands east of the mountains. Quito, the capital, is on a plateau in the interior. Although on the equator, Quito, because of its altitude, has a delightful climate resembling that of perpetual spring."

In this quotation, the student has used the names of 6 of the 85 places indicated on the map. These are Caribbean Sea, Barranquilla, Magdalena River, Columbia, Ecuador and Quito. The essay was continued until all of the 85 places were used and the return journey completed by way of the Atlantic, New York, and Chicago. This study required:

1. The planning of a definite route of travel covering a total of many thousands of miles.
2. The writing and also the pronunciation of 85 names of importance in the geography of South America.
3. The independent and intelligent use of textbook, geographical readers, and other sources as reference books to accomplish a definite piece of work outside of textbook routine.
4. Careful attention to the correct use of English in the writing of an essay of 1,500 to 2,500 words.
5. The visualization of the journey more definitely than if the student had read a similar description prepared by some one else.
6. The thinking of the continent as a unit with its related countries, physical features, and cities.

The writer has had hundreds of students in normal school and in the elementary school carry out exercises similar to the one here indicated. The work has been accomplished with the interest of a popular game. Essays of real geographic merit have been produced. The mechanical, uninteresting learning of place geography disappeared with the introduction of the journey essay. It is hoped that this experience may be suggestive to others.

CLASS ROOM SAYINGS.

"One difference between the stars and planets is that the stars have a warmer temperature than the planets. Another difference is a difference in size, the planets being the smaller. Another difference is that the planets are in a solar plexus and the stars are scattered all over.

PLANT LIFE AND HUMAN AFFAIRS.

By Clifford H. Farr,

State University of Iowa, Iowa City.

The World War served to bring to light a tremendous development which has been going on for the past quarter of a century or more in that branch of human knowledge which has to do with plant life. This great catastrophe to modern society had at least this virtue: that it compelled us to lay aside for a time the superficialities and luxuries of civilization and get down to fundamentals.

Food. Not only the vegetarian, but every human being, regardless of his diet, must admit that every particle of energy-giving food is ultimately derived from plants. Beef and mutton in so far as they are food at all are solely the products of the activity of the leaves of the grasses on the hillside stored in the bodies of animals and there preserved for the consumption of man or other animals. Pork is the nutrient materials in the corn kernels or in other plant structures preserved in the bodies of swine, which add nothing to their value as foods but simply transform them into other types of food which may be more or less palatable according to the taste of the consumer. All food is formed by the chemical processes in the leaf which take place by the energy of sunlight. These chemical reactions have not thus far been duplicated by man, except in so far as he has used the compounds which are obtainable only in plant tissues. And this artificial production has thus far been possible only in amounts which are barely detectable with the most refined chemical methods. Botany is thus the only subject which deals with the ultimate source of the world's supply of food. Indeed this is the original meaning of the word. The ancient Greek went out on the hills with this *bous*, and when asked why he drove his cattle to the fields he replied *boskein*, to feed. And when asked what they ate he replied *botané*, that which is eaten. Our recent conception of this subject as simply a study of flowers is therefore a perversion of its meaning and we are only getting back to the original conception of the term when we extend it to include the origin and sources of food materials.

Botany lies at the foundation of the study and development of agriculture. In agriculture there are three primary considerations; the soil, the crops, and the farm animals. The soil is of no interest of significance except as it is the substratum upon which plant life develops. It supplies the nutrients for the field

and truck crops and only in so far as it does so is it of any moment to the farmer. In modern times when the draft horse has been supplanted by the tractor, the chief significance of livestock on the farm is that it consists of living motile storehouses of the plant food materials. All of the food substances contained in the body of the cow or the hog or the sheep are derived solely from the plants upon which these animals feed and are only formed in the leaves of such plants. The plant then is the central feature about which farm life and activities are built; and it is therefore very obvious that a thorough knowledge of plant life is absolutely essential to the proper prosecution of that industry.

But it is not only to the farmer that the plant, as the source of food materials, is of interest and importance. The physician and the dentist are finding more and more that matters of diet are of great importance in the prevention and cure of disease. The most recent advances in dentistry have to do with the effects of the various foods in the decay or preservation of the teeth. And one of the conspicuous developments of the past decade in our hospitals and medical institutions is the organization of the nutrition laboratories. The important constituents of foods are studied, the plants and animal products which will give the proper energy in the most desirable fashion must be known; and in all this the knowledge of plants is important because they comprise by far the greater number of kinds of foods and they are the original source for all of the energy in any food and the source of the vitamines as well.

But the physician and dentist are interested in plant life for another reason. Many of the diseases of human beings as well as of animals and plants are due to microscopic parasitic plants. The bacteria are now known to be very minute plants which have abandoned the habit of manufacturing their own food by the aid of sunlight; and have undertaken to obtain their food from other living things, thus becoming parasites. Not only bacteria, but an increasing number of fungi are found to be of importance a causes of human diseases.

And there is a third çause for interest in plants on the part of the physician and dentist. The word "food" may be extended in its broadest sense to include drugs, which are substances of a beneficial nature introduced into the animal body. The pharmacist finds that by far the greater number of drugs come directly from plants. The plant is an organism which has protected itself against disease by storing its waste materials within its

body in quite the opposite manner from that in which the animal disposes of its waste products. If the animal is to be protected against diseases or their ravages it is advisable that there be introduced into the body of the animal some of these plant materials. This is the fundamental principle which underlies the treatment of diseases, that is their therapeutics, by the action of drugs. The pharmacist has therefore a very direct use for the study of botany; and in the regular curriculum of the College of Pharmacy, one-twelfth of the entire time is devoted to a study of the types of drug plants and their structure. This is in addition to the time devoted to a study of the commercial forms of the plants as they are on the market and the way in which they are prepared and used for medicinal purposes.

Fuel. Not only are plants the sole source of energy-giving foods, but in like manner they are the ultimate source of all of the heat-producing substances in fuels. For many centuries prehistoric and historic man depended directly upon plants for their fuel supply. Even today wood is the only fuel in some districts, and it is little more than a century that other fuels have been employed extensively in any locality. But coal is just as truly a plant product as is wood, the only difference being in the length of the period of preservation between the living condition and its combustion. Oil and gas though not quite so directly plant products are really transformed vegetable substance of heat producing value. According to our best imformation oil and gas are the transformed bodies of animals of past ages, and the compounds in them which are valuable to us are only the organic compounds of their vegetable food altered but slightly in the metamorphoses which took place in their bodies and in the earth after their death and burial. The forest engineer and many mining engineers are thus directly or indirectly concerned with plants.

There are at present very marked indications of a return to the plant more directly as a source of fuel. It is obvious that the coal, oil and gas of the earth are being consumed at a very much more rapid rate than they are being formed. This means that it is only a question of time until mankind will be again wholly dependent upon the plants which are living today for its fuel supply. The Standard Oil Company is already undertaking researches in the production of alcohol from corn stalks on a commercial scale. Our forests and our field plants will have to be looked to as a source of fuel as well as of food and structural

material, and the problem of supplying the increasing population of the earth with these necessities is one that falls directly at the door of the botanist.

Fabrics. It is thus seen that the two most important necessities of modern civilization are entirely derived from plant life. It now appears that the same is in most instances true of the third member of the group of fundamentals. Among our fabrics we would perhaps place cotton and linen as very nearly the most prominent and widely used. Their mention is sufficient to indicate their plant origin. While the other two primary textiles, wool and silk are not directly of vegetable material; yet the silk-worm is helpless in finding substances for its cocoon without the mulberry leaves, and the sheep could not produce wool without grasses for food. Here again we have instances of vegetable material transformed into animal tissue which then becomes useful to man. In addition to these primary textiles there are the many fibers which the tropics and the orient have in recent years given us. These include manila hemp, ramie, jute and others; and almost without exception they are the integral parts of living plants extracted and prepared for commercial purposes.

But the word "fabrics" in its broadest sense should probably include other commercial stuffs than the textiles. It may be taken to refer also to the various structural material with which modern society deals. Here lumber will doubtless have first place, both from the standpoint of its historical priority and its adaptability. Perhaps no material can be found that is as readily worked, as light compared with its strength, as good a non-conductor both for heat and electricity and as resistant to strains and stresses due to its high elasticity. Of course, iron, cement and aluminum may have some advantages from the standpoint of freedom from decay and combustion; but methods have been found for satisfactorily preventing the decomposition of timber by disease and it seems only reasonable to expect that the elimination of the danger of fire may be found feasible in a similar manner. Perhaps the supply of these structural materials of mineral origin gives promise of lasting longer than does the supply of timber; but it seems hardly likely that lumber will be relegated to an inferior place from choice at least, on account of the valuable properties mentioned above and also because of the aesthetic appeal of its grain. Many people are professionally interested in plants on account of their use as fabrics.

Not only the housewife and the cotton and linen manufacturer, but the forester and the building contractor as well use plants in this way. Those types of engineering which have to do with construction work of any kind use forest products to a greater or less extent.

Perhaps the business man seems most remote from the field of plant life; and yet the student of commerce must be impressed with the enormous number of raw materials, both food, fuel, fabrics and structurals which are directly plant products. The intimate nature of the manufacturing processes by which the raw materials are transformed into the finished commodities of commerce are dependent very frequently on the intimate structure and composition of the plant materials which are employed. In fact, it is doubtful if there is any branch of science which contributes more to the knowledge of the materials of commerce than does botany. Rubber, paper, vegetable oils, commercial fertilizers, lumber, textiles and many foods are among the principal commercial products whose origin and value can only be understood through a knowledge of botany.

It may be that the person who becomes heir to large land holdings feels that he has little need for information regarding the vegetable kingdom. He can hire someone to care for his agricultural work and do his marketing. And yet if he is to become at all efficient in managing his estates, in attempting to improve his real properties, to drain and landscape them so that their value to man and especially to himself will be increased, he must take recognition of the part which plant life plays in the development of his holdings and of what possibilities there are in this direction. It is especially important in the case of timber lands which lie about the headwaters of streams from which it is planned to derive waterpower through the construction of dams or the use of natural waterfalls.

Force. While food and fuel are entirely of plant origin and fabrics are largely such, the same cannot be said of mechanical power. And yet plant life has a direct relation to the more common sources of mechanical energy which are now in use on a large scale.

Two primary sources of energy may be distinguished on the earth, namely the sun and the moon. Of these the sun is the principal factor, though the moon causes an enormous expenditure of power every day in the form of the tides. In the past, few attempts have been made to harness this force and make it do work for man. The well-known Back Bay of Boston is

name from the fact that it was at one time an artificial tidal basin for the purpose of deriving power. Another attempt is now being made in the same vicinity to secure energy from this source. How successful it will be can only be revealed by the future.

The sun's energy is expressed in various ways. Never as yet has it been converted directly into a useful form on a practical scale. The solar engine which Arrhenius predicts will revolutionize modern civilization is still in the future and we are now forced to accept the sun's energy second hand. It is displayed in the form of fuel, animals, wind, rain and waterfalls. The first has already been discussed above, and the second includes human labor and the work of such animals as draft horses, oxen, and dogs which is really the liberation of the energy in the food of these animals. The day of the windmill is passed temporarily at least. Perhaps in the not distant future it will be revived to take the place of the gas engine which has so recently usurped its domain. Rain has never been used as a source of power although it is estimated that 30 millions of horsepower is expended by this factor upon the earth's surface in the United States every year. There remains then waterfalls as our principal source of mechanical energy.

The engineer is interested fundamentally in two lines of endeavor: one is construction, the other the converting of one form of energy into another more useful form. In the deriving of energy from waterfalls either natural or artificial he has to consider plant distribution and activity. The efficiency of the waterfall from a commercial standpoint depends very largely on the rate of flow being kept constant through the year. This constancy of flow in turn is dependent on the vegetation of the headwaters of the stream. An efficient power house cannot be maintained with a flood at one season and a dry stream bed at another. It is estimated that two-thirds of the rainfall is used by plant life and that only one-third is present in the run off from a given tract of land. This means that the vegetation of the region is a tremendous factor in the prevention of floods. It explains the scarcity of floods during the summer months and their occurrence in part at other seasons of the year when the plant life of the region is using little or no water. In flood prevention work then the engineer is interested in plant life.

Friendship. It is perhaps very fitting that the flower should have become among all peoples the symbol of friendship. We

have seen above that plant life is fundamentally related to each of the four great necessities of modern life. These four constitute the foundation of human happiness, which lies at the basis of friendship. Friendship has been called the keystone of the arch of civilization, but without the other four blocks named above the keystone of the arch could not maintain its position. These four stones rest upon the pillars of the plant kingdom, and together plants producing food, fuel, fabrics and force form a firm foundation for the friendships of human society in the largest sense of that word.

The lawyer and the law-makers are the guardians of our local, national and international peace and friendship. The fact that society is so founded on plant activity and plant products means necessarily that the professional man of this type must be more or less familiar with the vegetable world. A considerable number of legal cases each year center about the questions of the adulteration of foods, and drugs, their poisoning, and the decay of fruits and vegetables which have not been properly handled in storage. It is not unusual for the lawyer to find himself in a position of distinct advantage in a lawsuit if he realizes the use to which the microscope and the information of the botanist can be put in the determination of the actual situation which exists, and also realizes the limitations of such types of investigations. In our day also a very common problem for the lawyer is that of the home still and home brewing. The raw materials used in these processes are all from plants, and familiarity with their decomposition and the fermentation processes may sometimes prove of value.

And the professional man in an agricultural country, whether a banker, lawyer, doctor, or teacher, will find familiarity with plants of importance in his friendships because he will be dealing with people all of the time who are devoting their lives to plant growth. He will be a leader in his community and as such should have a grasp of the fundamental principles underlying agriculture, and above all a sympathetic attitude toward the grower of crops. When a crisis arises and disease or pests are menacing the crops, he should know what move to make to bring most rapid assistance to the citizens of his community. He should have some basis of judgment as to whether a suggested remedy is scientifically well founded.

And the professional man outside of his business life needs botany. Most of the foods which he and his family eat, much

of the clothes which they wear, and all of the furniture, and finishings and floors of his home are of vegetable origin. His garden, his orchard, and his lawn have their chief interest centering about the plants which grow there; and as he drives to the country on the holiday his wife and children will enjoy it more if they can understandingly meet the trees and flowers which grow by the wayside, or which they find near their camp in the woods.

The professional student is wise who prefaces his special course with a year or more in a collegiate school. Here he can get valuable information and some of the fundamental principles upon which his professional work is based. Not the least of these advantages is the opportunity of an intimate knowledge of plant life and behavior which comes through courses in botany.

With this increasing familiarity with plants, especially among an agricultural population, it becomes more and more necessary that novelists and playwrights, as well as journalists, should increase their vocabularies and enhance their powers of description, by an intimate knowledge of plant forms and structure. Certainly nothing could be more crude than to witness moving pictures which purport to be taken in Chicago and notice that the trees and shrubs in the background are those of California. Quite as uncalled for is the omission in the descriptions found in novels and short stories of the common names of plants. If these writings are to have great educational value they should at least encourage an interest in the things of nature about us.

Recent developments in the study of history and sociology are bringing to light the fact that the various movements of peoples in the past as well as at present, the occurrence of wars and social upheavals such as bolshevism are to be directly traced to the vegetable life of various regions. Many migrations and the travels of nomadic tribes are found to be related to a decrease in the fertility of the soil of various regions and a change in the flora of a locality where for instance a population depending on grazing for their livelihood was situated. The types of plants which a locality will support determines in large measure the size of the population and more especially their occupations. Any change in the flora due to decrease in soil fertility or introduction of diseases and pests will very critically affect an agricultural population, as most populations in the past have been, and drive the people to migrate, or make war on their neighbors, or may lead to their extinction.

Civilization arose in the lands of Egypt and of China and now the peoples of one of these countries are dying of starvation because the lands will not support adequate plant life. Babylonia likewise rises early on the horizon of history and was succeeded by the civilizations of the Chaldees and Assyria. In very early days Abraham went up out of Ur of the Chaldees and dwelt in the plains of Jordan and became exceedingly rich in cattle, not only because this new country gave more room for expansion but because the fertility of the soil and hence plant growth was more favorable. Now the Arabian desert has encroached upon this fertile valley and the center of human activities has long ago migrated westward. First to Greece, then Rome, and thence northward to what came to be England, France and Germany. England's success as a nation and her dominance in recent years are to be attributed entirely to her many dominions and colonies in new regions of the globe where plant life thrives at its best. France has long suffered for lack of colonies sufficiently rich to support her life, and Germany has just passed through a period of tremendous agony because her population could not longer continue upon the plant life which was available within her empire. Bolshevism has been running rampant in the countries of eastern Europe especially because of lack of food and fuel. Truly it seems that we have had abundant evidence as to the dependence of human friendships and the perpetuity of modern society upon an adequate supply of plant material of the proper kind.

The world has now been encircled by civilization. By its westward movement America has today become the center of its highest development. By the products of our fields we are in large part feeding both the orient and occident of the Old World. There are now no new lands to explore and exploit. Civilization must be content to proceed as best it can on the resources now available, and in the development of these resources to the highest point of efficiency the botanist is sure to have a very prominent part.

ON THE NATURE OF THE OSMOSE.

By Creig S. Hoyt,

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The nature of the phenomenon of osmosis and the osmotic pressure is a question that has long been disputed. The discussion has recently been allowed to rest without reaching any decision; largely, because of the fact that regardless of the nature of the osmose, it affords a means of reversibly and isothermally separating solute from solvent at low temperatures. Regardless, then, of the nature of the mechanism of the process, the thermodynamic deductions from it would be the same, provided, of course, that the separation was quantitative.

However, textbook writers have recently introduced into the course in general chemistry the methods of determining molecular weights in solution, deriving these methods from those involving vapor densities by the analogy of Vant Hoff between the solution and gaseous states and utilizing especially the quantitative measurement of osmotic pressure. Because of the fact that this reasoning is based on analogy, the derivation must be made on kinetic rather than on thermodynamic grounds. In order to do this, the textbook of general chemistry tacitly assumes the validity of the kinetic explanation of osmotic pressure. It seems advisable, therefore, to inquire into the evidence for the kinetic theory.

The question is really a two-fold one. We are interested in the cause of the flow through the membrane and the part the membrane plays in bringing it about. A second question really independent of the first is the source and nature of the resulting pressure. Osmosis may be defined as the passage of a solvent through a membrane which is permeable to solvent but not to solute, in the direction of the more concentrated solution. A membrane which, within practical limits, prevents the passage of solute while allowing that of the solvent is termed semi-permeable. Perhaps no membrane is absolutely semi-permeable but membranes of copper ferro-cyanide precipitated in the walls of specially prepared earthenware cups are so nearly semi-permeable that they may be so considered. The first question is the cause of the preferential action of the membrane.

One view which was advanced by Jäger is that the membrane is built up of minute capillaries through which the solvent is carried from the region of pure solvent to that of the solution because of the higher surface tension of the solution.

This finds favor especially with physicists but it makes some assumptions which are hardly tenable in all cases. For example, it assumes that the surface tension of every solution is greater than that of its solvent. This is not always true, by any means, and many cases are known where the osmotic flow occurs in the opposite direction from that predicted by the theory. Moreover there can be no proportionality between the osmotic pressure and the surface tension of a solution since the one is proportional to concentration while the other is not.

A second view states that an attraction exists between water as solvent and the solute molecules with the formation of hydrates. The attraction, which the solute has for solvent is, according to this theory, purely chemical. This explanation has a considerable weight of evidence in its favor. But it seems certain that the amount of hydration necessary to produce the observed osmotic effect is far in excess of the amount actually noted by various observers. Moreover, there seems to be considerable doubt, even among those most friendly to the view, as to whether the degree of hydration changes with the dilution.

The third explanation is one calculated to find particular favor with chemists, since it accords with well-recognized laws regarding the process of solution. The solvent must be soluble in the membrane while the solute is not. Solvent from the region of pure solvent dissolves in the membrane. It attains a concentration in equilibrium with that of pure solvent which we will designate as c_1. This dissolved solvent is also in contact with solvent in the region of solution which is diluted with solute and so has a concentration c_2, less than c_1. In consequence there is a transfer of solvent from the membrane to the solution in an effort to restore equilibrium. The membrane is then unsaturated with regard to c_1, as a result of the transfer to the solution and more solvent dissolves in it. Equilibrium can only occur, then, when the solution has attained an infinite dilution or external pressure has been applied to overcome the flow. This external pressure, which is equal to the pressure of the osmose is that which must be applied to prevent any dilution. The success of rubber membranes with benzene and copper ferrocyanide, cut with water as solvent, points to the validity of the explanation.

But there is still a better piece of evidence, based on the analogy of Vant Hoff. Indeed, Vant Hoff, himself, predicted the details of the experiment although it remained for the ver-

satile Ramsey to perform it. A vessel of palladium, which served as membrane, contained nitrogen. Surrounding the vessel was an atmosphere of hydrogen, which is soluble in palladium. Here were the conditions essential to an osmotic transfer and hydrogen did pass through the walls of the vessel into the interior while nitrogen which is insoluble in palladium could not pass out. Gaseous osmose! Indeed it seems that here we have an explanation of osmotic transfer which is both good and sufficient. Vant Hoff seems to have been amply justified in his conclusion; "There is a deep-seated analogy—indeed, almost an identity—between solutions and gases, so far as their physical relations are concerned."

But what about the nature of the pressure developed? The simplest consideration of osmose would be that in which the transfer continued until the solution was diluted to an infinite degree. No question of pressure arises here and it is easier to formulate than any other case. The flow can be prevented after an insignificant amount of dilution, by the application of external pressure. This applied pressure is the measure of the unbalanced force between solution and solvent and consequently must be characteristic of the solute and proportional to its molecular concentration.

Let us return to Ramsey's interesting experiment. The nitrogen in the palladium vessel has a pressure P_h. The hydrogen outside has a pressure P_n. When equilibrium is restored by the transfer of hydrogen into the vessel, the pressure of hydrogen inside the vessel must be the same as that outside, or P_h. The total pressure inside the vessel must be equal to P_h plus P_h, or the sum of the partial pressures. The excess pressure inside the vessel is due to the nitrogen and is equal to its partial pressure, that is, the pressure which it would exert if it filled the vessel alone. Regarding the hydrogen as the solvent, excess pressure due to the passage of hydrogen through the membrane is due to the solute nitrogen through the kinetic energy of its molecules. Hydrogen is transferred but the pressure is due to nitrogen.

Effects similar to that of Ramsey may be obtained with wet parchment as membrane, air as solute and ammonia gas as solvent. An osmotic effect may even be obtained momentarily by surrounding a porous cup filled with air by a bell-jar containing hydrogen. To be sure, the osmotic effect rapidly dies away since no claim to more than a differential permeability

can be made for the cup. Reasoning from analogy, the kinetic theory seems to be the only one that is at all tenable.

But even better evidence may be had! The osmotic pressure of a solution is directly proportional to the absolute temperature. In other words, at the absolute zero, where molecular movement ceases, the osmotic effect disappears. Only kinetic phenomena, such as the pressure of gases and the electrical conductivity of metals, are proportional to the absolute temperature. Kammerlingh Onnes found that a current induced in a pure metal circuit at the boiling point of helium (−268°C) flowed for a long time before it died out. The perfect chain of polarized molecules must have been little affected by any kinetic movement at this low temperature. If osmotic pressure is proportional to the absolute temperature, it must be a kinetic phenomenon.

To quote Vant Hoff again, "We are not dealing here with an artificially forced analogy but with one which is deeply seated in the nature of the case. The mechanism by which according to our present conceptions, the elastic pressure of gases is produced, is essentially the same as that which gives rise to osmotic pressure in solutions. It depends in the first case, upon the impact of the gas molecules upon the walls of the vessel; in the latter, upon the impact of the molecules of the dissolved substance against the semi-permeable membrane, since the molecules of the solvent, being present upon both sides of the membrane through which they pass, do not enter into consideration."

"AMERICAN" IN TEACHING CHEMISTRY.*

By Harrison Hale,

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The emphasis on American in teaching chemistry has varied from the below zero effect given in some of our courses before the war, where the emphasis was European and America was forgotten, to the 100° in the shade effect in certain of our courses during and immediately following the war, where the emphasis was American and the rest of the world forgotten. But between these extremes there is a rightful, normal emphasis.

Such an emphasis should be reasonable and based upon facts

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as they are with a vision of possibilities in the future.

This emphasis can best be given by keeping in mind:

1. American chemical history and achievement
2. Magnitude of American resources
3. Fundamental importance of chemistry to America
4. American responsibility and opportunity.

It seems wise to the writer that very early in his beginning course the student should know that the first chemical society was founded in America—the Chemical Society of Philadelphia in 1792. Experience has proven that a statement in regard to Priestley's coming to America, his life here, the centennial celebration of the discovery of oxygen held at his grave and its connection with the founding of the American Chemical Society, now by far the largest organized body of chemists in the world, adds interest and increases attention at a time when many a fellow in the class is beginning to wonder what chemistry has to do with him any way.

Many another historic fact of value can be found in "Chemistry in America" and other books by the distinguished president of our society, Dr. Edgar F. Smith.

In the discussion with the class about nitrogen comes the question of explosives with American war-time production and their peace-time uses; of foods and of fertilizers with their fundamental importance. Under water is noted the American system of rapid filtration and the use of chlorine as a sterilizer chiefly developed in this country. This may be again suggested in studying the halogens as a peace-time use of this element so widely used in war gases.

The development of a dye industry, of optical glass, of the beginnings of a potash industry is a series of achievements that can well cause pride in every American.

All of us know in a general way that America is big and great. Does the average college student have any definite conception as to the real magnitude of American resources? Some such conception can and should naturally be given every student in general chemistry. Under the carbon chapter the student will be glad to know that the 1920 production of coal in the United States was 645,000,000 tons, or 45% of the world's production, while all of Europe produced 46%.[1] Our reserve coal supplies, the possible determining factor of future greatness, exceed all others, one little state, West Virginia, having

1. Science, n. s. 53, 431 (5-6-21).

greater stores of coal than Great Britain and Germany combined.[2] In 1920 the United States furnished nearly two-thirds of the greatest annual production of petroleum, and together with Mexico 87.5% of the world's output.[3] Our daily production of 51,000,000 gallons is greater than the water consumed by any of our cities except ten or twelve of the very largest.

Similarly our cement production of about 90,000,000 barrels exceeds that of any other country.[4] So also with iron and steel, copper and aluminum. In agricultural production our 3,000,000,000 bushel corn crop is 75% of that of the world, our cotton crop 60% and our wheat 25%.[2] In number of our automobiles, of telephones, of miles of railroads and of telegraph lines our pre-eminence is almost beyond belief.

The greatness of our resources was most strikingly brought home to the writer by an article by Dr. Arthur D. Little in the Atlantic Monthly on "Developing the Estate."[2]

The fundamental importance of chemistry to American life and industry can be made apparent in almost every lesson. It must be clearly kept in mind that the field of the chemist is far broader than than of the so-called chemical industries. The fact is that but a very small fraction of the billions and billions of dollars worth of American manufactures is not either directly or indirectly dependent upon the work of the American chemist.

Many magazine and newspaper articles are chemical or of chemical interest and some students will readily note this and report upon such articles, forming a habit in their current reading of much value for the future. The recent visit of Madam Curie furnished an unusual opportunity for presenting America's share in radium production. The accounts of the awarding of medals, such as the Perkin medal, both current and past, are rich in material and all Americans should know of the work of Hall, of Acheson, of Gayley, of Cottrell, and of many others.

The fundamental importance of our dye industry in national defense and of a survey and co-ordination of our industries, as suggested by Grosvenor Clarkson in a recent article in the Review of Reviews,[5] can be mentioned and will be understood. Slosson's "Creative Chemistry" is a veritable mine of interesting information.[6]

Having gained some conception of American achievement,

2. Little—Developing the Estate. Atl. Monthly 123, 381 (Mar. '19).
3. Preliminary Figures, American Petroleum Institute, newspaper clipping (2-17-21).
4. Hale—American Chemistry, p. 131. Van Nostrand (1921).
5. Clarkson—Industrial Preparedness, R. of Reviews, 64, 71 (July, '21).
6. Slosson—Creative Chemistry. Century Co. (1919).

the magnitude of her resources, and the fundamental importance of chemistry to America, we are then ready to emphasize America's tremendous responsibility and her unbounded opportunity. Not in the history of the world has any nation had greater opportunities for growth and leadership not for the conquest of the world, but for the service of the world.

It was the writer's pleasure in giving a course in American Chemistry this summer to notice how naturally and readily the class recognized this responsibility and this opportunity.

To one other American product and resource I wish to call your attention in closing. Today there are nearly 2,000,000 students in our secondary schools, eight times the number of such students a generation ago, and more than in all the rest of the world.[7] They are prospective students of chemistry in high school and in college. To us is offered the God-given opportunity of showing them America's achievement and power, of making them know the fundamental importance of chemistry in the solution of American problems, of giving them a vision of America's possible service to the world.

7. Report U. S. Commissioner of Education.

APPLICATION OF EDUCATIONAL PSYCHOLOGY TO CHEMICAL EDUCATION.

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Chemical education must be built on the same psychology as every other subject. The chemistry teacher has the same personal equipment with which to work. His or her work should consist in using chemistry to modify certain original tendencies of the student. The degree of modification will vary with the different tendencies. In some cases there will be such a slight modification that the original tendency will appear to be perpetuated, while in other cases the modification will be so great that one might think that the original tendency had been eliminated, but it has not. It has been transformed, and this transformation may amount to the negative of the original tendency.

The original tendencies which the chemical educator can best modify are: curiosity, manipulation, possession, fear, mastery, approval, rivalry, company, sex instinct, imitation. The degree that these original tendencies can or should be modified by the chemical educator will be discussed under separate headings.

Curiosity.—There is no subject that is able to do more than

chemistry to stimulate the tendency of curiosity. On the other hand there is no subject today that is doing more to eliminate the spirit of curiosity than college chemistry. Why is this? This is because the student is told or has read everything about his subject before he is given a chance to satisfy his curiosity by the manipulation of his own hands. The experimental facts, which should hold the spark to touch off his curiosity, have been bathed by the learned professor's wonderful knowledge until the spark is entirely extinguished. He has no desire or curiosity to experiment, for he knows that such work is only to illustrate the textbook or what the professor has said. Illustrative work is highly artificial, gradually eliminates the tendency of curiosity, and finally finds the student with a created tendency of watching for results already known, and seeking to answer questions that arise by consulting the text rather than observing the experiment itself.

Manipulation.—Every child has a desire to handle new objects, to take them to pieces, and to put them together. This tendency is closely allied with curiosity. Manipulation is the very foundation of the experimental side of chemistry. It is termed the technic of the laboratory. The technic should be given considerable weight toward the final mark in chemical study. Very few theories worked out with even the most exact reasoning are accepted until they are put to the test of the experiment, hence the student's technic or manipulation must be equal to his reasoning or he fails. His curiosity, which has been aroused by his exact reasoning or by some suggestion, is often killed in a few minutes by poor manipulation. On the other hand, if he had had his manipulation highly trained, the results would have been entirely satisfying, success would have further stimulated his curiosity and lead him to higher planes of thought.

The student, at the beginning of his course, should be watched very carefully to see that he connects the proper neurones, and these connections should be made sufficiently often so that certain manipulations will become habit. The law of exercise is a very important law at this stage of the game. Habits of putting up certain pieces of apparatus should become so common that the pieces are assembled while the mind is reasoning about the experiment or making observations.

Mastery—Mastery might be treated under two headings in the case of chemistry, (1) the leader of his class, and (2) mastery of the chemical work. No (1) will be treated under rivalry, and only (2) will be discussed here.

The first step is to find a task worth doing, the second step is to arouse the curiosity, and then let the task require no more complicated manipulation than the student is equal to. If he masters this first task successfully, and he sees that it is worth while, he is in excellent shape for tackling the second task. Each succeeding task should grow very gradually in its degree of hardness. It might be said that one is building by the law of association. If there is the proper transition, the time comes when the student almost thinks that there is no task too great for him. His fighting-bullying mastery has been modified to the master of truths.

Care of Possession.—Some laboratories have done much to train the tendency for the proper care of possessions. Each student should be given a desk and in that desk he should find every piece of apparatus and every chemical necessary for his entire course. The workshop is his desk and it is entirely his own. He is responsible for everything in it. It trains him in an economical use of his possessions, and to guard them properly. A failure in either case costs him money, and there is no greater annoyance than to be deprived of money, for he knows that money gives him satisfaction.

Collecting.—Collecting and hoarding should be cultivated to a certain extent. I have found that students are very interested in carrying home the various chemical compounds that they make in the laboratory. The fact that they have produced them with their own hands adds greatly to their value in their own estimation, and hence stimulates their desire to collect these specimens, and the very fact that they are going to save them adds to the efficiency and quality of their work.

Fear.—Fear may be greatly modified by chemistry. For instance, I knew a girl who would not light the gas range at home. She had the same fear about lighting a Bunsen Burner, which is constructed on the same principle as the gas range. I found that the "striking back" caused all her fear. When she had taken apart the Bunsen Burner and really found out what was the cause of the "striking back" her fear vanished. They discover that the way to find if a thing is harmful is to learn the facts about it. This is further emphasized by a study of the chemical compounds. If the proper spirit is carried, the student will learn to fear only ignorance, and hence have a greater desire for knowledge.

Rivalry.—Rivalry can be modified very well in chemistry.

One way to develop rivalry in chemistry is to let each student go as fast as he can. This can be done by allowing the brighter students to forge ahead, keeping the lectures and discussions just back of the slower students. This plan does not work well in large classes, but is ideal for small classes. Rivalry keeps each man to his best every minute. It does more than this; it shows him that he must be up and doing if he is to hold his own in life's race.

Company.—Most students have a desire to work with other people. I have given this quite a bit of attention, and I am convinced that it is one natural road of learning. But if it is to work out to the best advantage the student must, in most cases, select his own company with whom to work. He will pick out some one satisfying to himself. In a majority of cases the party with whom to talk over his experiences will be near his equal in ability. Since this is satisfying to them, he has the correct "setting," and the proper neurones are ready to make connections When two students have talked their problems over together they have made many different bonds between the situation and the response, and hence they are unconsciously practicing the law of exercise and effect.

Sex Instinct.—Sex instinct is very closely allied with company. When the sex instinct begins to appear, each wishes to do and appear his or her best in the presence of the opposite sex. In this way instinct can be used to the very greatest advantage to bring the very best out of the boy or girl, but no better in chemistry than in any other subject.

Imitation.—Some of the first manipulations in experimental chemistry, may well be done by the teacher. The student imitates this manipulation in trying to get a result similar to the result obtained by the teacher. In a way he is working for approval and effect. In this exercise he is using imitation to strengthen certain bonds.

Approval.—Approval can be used to quite an extent in the chemical laboratory in a personal way. Just a word at the proper time means a great deal to a student. Approval in an unique manipulation, or the successful mastering of some undertaking can be done personally in the laboratory without setting up any annoyance for some students less fortunate, who have a great tendency for jealousy.

Associate Learning.—Educational psychology speaks of learning as consisting of connection-forming, involving (1) multiple

response, (2) ideas, (3) analysis and abstraction, and (4) selective reasoning and thinking. In the process of learning chemistry each law is used and practically in the order given.

When the student goes to the laboratory for the first time, all pieces of apparatus are new to him. He does not know the name of the different pieces, and much less does he know the use of them, or the precautions to be employed in their use. Full directions by the instructor and many cautions do not prevent him using very inefficient and many times entirely wrong methods. He only learns by trial or multiple manipulation that you must not let a blaze get above the water line in a beaker or flask, that you must keep the end of the delivery tube out from under the water when you cease heating the flask. There are a great number of cases of this sort where the student only learns by the trial and error method. In fact, this happens all through his laboratory work to a certain degree, but becomes less and less as his knowledge of the subject grows. He is annoyed by the wrong manipulation, and satisfied by the correct one.

In chemistry a great part of the first year's time is spent in connection-forming, involving ideas. It is the failure of the teacher to honor this law that counts for many failures in freshman chemistry. The instructor does not realize that chemistry presents a new language, and it is not until the student acquires these new concepts that he can progress in learning the new facts. When you tell him to find out such and such a result by experiment, and then in the direction of the experiment he finds that he should use so many c. c., in a 200 c. c. flask, and place the flask on an iron stand supported by a wire gauze, so much of his mind is taken in connecting the idea with the different pieces of apparatus that he will often forget what result he is trying to get, or, at least, fail to make half of the observations, which he should have made. The instructor must go slowly until the student has formed the habit by the law of exercise and effect of connecting the concept with the different pieces of apparatus, and the different chemical terms.

Analysis and abstraction should be practiced very early in the chemical course. For example, when he has found that he can obtain hydrogen by the interaction of zinc and an acid, it should be brought to the student's attention, if he does not think of it himself, that perhaps other acids or other metals might be used. When he finds out that other metals and other acids may be used, he has analyzed the situation, abstracted the methods

that may be used by applying trial and error, and has had his curiosity aroused as to why all possible combinations of acids and metals do not work. After this is once pointed out to him, he will wish to generalize every preparation. This results in a classification of his material, putting it in usable form, and gives him a breadth of experience that he can gain in no other way.

If the analysis and abstraction has been properly handled, you have placed the student in the highest perspective for selective thinking and reasoning. All experimental work and discussions should be classified and generalized to the fullest extent by analysis and abstraction and then when the experimentor has found certain results, he knows that they must have come from certain conditions. Dalton's hypothesis is a fine example of this. By experiments he found that the laws of Definite and Multiple Proportion were true, and then by selective-thinking and reasoning he formulated an hypothesis for the structure of matter. His selective-thinking was so keen and reasoning so exact that up to the present day his hypothesis stands intact. The advancement of chemical knowledge depends largely on selective-thinking and reasoning. Theories and hypothesis are advanced, and then by experiment these theories and hypothesis are verified.

From what has been said, it is evident that chemistry may be used very effectively in leading the student from the very rudest kinds of learning, namely, the trial and error method, to the highest type of learning which is selective-thinking and reasoning. In fact all four laws of learning should be constantly employed.

GERMS PASS THROUGH CISTERN FILTERS.

Cistern water that is used for drinking should be gathered with great care. Properly constructed cisterns that receive rain water from roofs generally afford good drinking water, but water of doubtful quality that is stored in cisterns is of course not safe for domestic use. According to the United States Geological Survey, Department of the Interior, most of the filters that are used in connection with cisterns do not remove the germs of disease, though they may make the water clear and apparently safe. Many cisterns are divided into two compartments by a brick wall, the water being admitted into one compartment and pumped or drawn from the other after it has passed through the wall. The passage of the water through the brick improves it in clearness and color but not generally in sanitary quality.

TEACHING PROPORTIONS IN GEOMETRY AND ALGEBRA.

By Jos. A. Nyberg,

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Whenever there is a decided break in the subject matter, such as happens in a geometry class between Book II, dealing with circles, and Book III, dealing with proportions, I have found it interesting to introduce the new subject in some dramatic way in order to catch the attention of everyone in the class. After stating that we are to consider a new subject and asking the pupils to close all books, put aside papers, pencils, etc., I clean the front blackboard slowly and apparently taking unusual care to erase every vestige of any chalk. Then I write in big figures $2/3=4/6$; for its psychological influence on the class I may, perhaps, erase one of the figures and rewrite it several times, as if I were not satisfied with its appearance. Then when I have everyone's attention I ask someone to tell me what I have written. The first answer is always a mere "two-thirds equals four-sixths" followed by some pupil, evidently repeating the subject, stating "a proportion." By continuing the questions I can get such answers as "two fractions," "two equal ratios," "an equation." I ask what names we have for the numbers 2 and 4, what names for 3 and 6, and thus the various terms are introduced. It is interesting to note that we have names for every pair of numbers selected; thus, 2 and 4 are the numerators (why bother with the word antecedents when the pupil already knows them as numerators), 3 and 6 are denominators (the word consequents is just as superfluous as the word antecedents), 2 and 3 make up the first fraction, 2 and 6 are the extremes (or "ends," if the proportion is written 2:3::4:6), and 3 and 4 are the means (the "in betweens" in distinction to the "ends").

After defining the various terms and replacing $2/3 = 4/6$ by $a/b=c/d$ the next question is: What is the easiest way of finding out whether or not two fractions are equal? Is there some way of *testing* whether or not 5/7 equals 63.9/92.3 without simplifying the second fraction? The answer leads to the

First Proposition: In any proportion the product of the means equals the product of the extremes.

With this as a fundamental proposition I write on the blackboard all the possible proportions that can be formed by using the numbers a, b, c, d, such as $a/c = b/d$, $a/d = b/c$, . . There are twenty-four, but not much time is required to write them all, if some system is used; for example, use a as the first term to

make three proportions, b, c, or d being the second term; then, three using b as the first term, c, d, or a being the second term; then, three with c as the first term, etc.; and after each proportion is written I write an additional one by inverting the right member but not the left. From these twenty-four we can at once eliminate twelve by agreeing that an equation in which the right and left members are merely interchanged is not essentially a new equation. We then use the first proposition to answer the question: If $a/b = c/d$ which of the other proportions are true? Of the eleven to be studied, eight are wrong since they lead to results other than $ad = bc$. The three remaining are

$$a/c = b/d, \quad d/b = c/a, \quad b/a = d/c.$$

In passing I might add that I plan to begin the work during the middle of a forty-minute recitation period, so that the assignment for home work for the following day consists in writing out the twenty-four possible variations and eliminating the untrue ones. Few of the pupils will get all of the twenty-four, and the lesson in how to get them by a systematic procedure is of value in teaching pupils the advantage of planning our work before merely "pushing a pencil."

Our next classroom work, then, is to translate the three results into statements, or, in the words used in the classroom: Without using the numbers a, b, c, d state in English: if $a/b = c/d$ then $a/c = b/d$. Thus we are lead to three fundamental operaations, applicable to proportions:

Second Proposition: In any proportion the means may be interchanged, the extremes may be interchanged, and the two fractions may be simultaneously inverted. The word simultaneously is inserted to guard against the inversion of merely one of the fractions.

There is no reason why these three facts cannot be combined into the one theorem, since they all involve the possible fundamental operations on a proportion. The statement is also very concise. Later when it is necessary to quote the theorem as an authority or reason, the pupil will, of course, state only that one of the three conclusions which he desires to use. It is also worth while to mention that these three operations or results make what is called, in other fields of mathematics, a closed system; that is, if after inversion we interchange the means, or interchange extremes, or follow any one of the operations by another one of the operations, we do not get a new proportion but merely repetitions of those already obtained.

Knowing now what operations can be applied to a proportion, because of the fact that proportions involve two equal fractions, we next observe that proportions are equations and hence any operation applicable to equations can also be applied to proportions. We may, for example, add any member to both members of the equation or divide any two equations member by member. If we add unity to each member and then simplify the result, we get $(a+b)/b = (c+d)/d$; adding -1 we get $(a-b)/b = (c-d)/d$. These results may be concisely stated as the 2.

Third proposition: From any proportion, a new proportion may be formed by adding the denominators to, or subtracting the denominators from the numerators.

This statement avoids the puzzling phrase "by composition" and the still worse one "by division." The word composition gives no clue to what the pupil actually does. Only tradition has kept such an absurd word alive. Composition, to be sure, in its derivation, means to put together and this implies addition; there is no reason why we should not say by addition. The word *by division* is still less justifiable, for actually there is not the slightest trace of any division; substraction is involved. As far as any use in geometry is concerned, these are the only properties of proportions which the pupil needs. The proportion $(a+b)/(a-b) = (c+d)/(c-d)$ so peculiarly referred to as "by composition and division" arises nowhere in geometry and is never used until the pupil reaches the law of tangents in trigonometry. And the proposition about the sum of the numerators divided by the sum of the denominators may also be postponed until the pupil is ready to use it later.

As homework for the next day I let the pupils see how many new proportions they can themselves derive by using any combinations of the five permissable operations that have been studied; for example, they may use inversion and then add denominators to numerators, or use any number of operations in succession, or add numbers other than 1 or -1, or divide any two proportions already obtained. They also investigate such questions as: May we add the numerators to the denominators, or add the extremes to the means, or add the means to the extremes, or add the third term to the first and the fourth to the second. The brighter pupils will be stimulated by competition to see who can bring to class the greatest numbers of new proportions. For those pupils who are careful to do no more than is required there must be something specific in the assignment,

such as finding one of the terms of a proportion when three of its terms are known. Or, I draw on the blackboard various figures containing isosceles triangles, circles, medians, the exercise consisting in deriving one proportion from another given one.

The classroom work the next day consists in considering for ten or fifteen minutes the results brought in by the pupils. Then we turn to the chapter on proportions in our textbook reading it aloud, discussing the new terms, and comparing the definitions and propositions with those we have discovered for ourselves. I find this work takes about twenty minutes, and while it could be omitted, I like to use and refer to a textbook as much as possible, in order to make the pupil well acquainted with his text and to create in the pupil a feeling of confidence in his book, so that he will not hesitate to use it freely as a reference book even after he has left the class.

The last ten minutes of the period are used in getting some ideas for the next day's work, which involves the proposition: A line drawn parallel to one side of a triangle divides the other two sides proportionally. I doubt if there is a theorem in all geometry which requires more careful explanation than this one because the meaning of *proportional* is decidedly new to the pupil. If we ask the pupil to state the theorem without using the word proportional we frequently find he has no ideas at all; and often he will copy the figure in the text and then try to prove some of the lines in it equal. For this reason some books state the theorem as: If three parallels cut two transversals, the segments on one transversal have the same ratio as the corresponding segments on the other transversal. But since the word proportional is so prominent in mathematics it seems better to use it and explain it rather than to dodge it. I have found it useful to emphasize from the very beginning two points which are easily overlooked, because they are so very obvious:

1. We can never use the word proportion unless we are talking about four quantities.
2. The operation of division is always involved.

Then whenever a pupil uses the word proportion in class he knows that he must be ready to answer immediately two questions that I always put to him: 1. What are the four quantities you are talking about? 2. The quotient (or ratio) of which two quantities is equal to the quotient of what other two? When the pupil has become acquainted with the teacher's idiosyncracies he will invariably forestall these embarassing interrup-

tions by stating at the beginning the four quantities under consideration. (The pupil says "Consider the four lines AD, DC, BE, EC," in much the same way as earlier in the course he said "Consider triangles ABC and DEF"), next stating the proportion and then finally using the word proportional as a conclusion or summary of his remarks. With this treatment I have been able to cure permanently the habit of saying that two lines are proportional when the pupil means merely that the lines are corresponding ones in similar figures. This emphasis on the two significant features of the concept enables us to use the word with a feeling that we know what we are talking about, and we can state the later theorems of Book IV more briefly than if we had dodged the issue and continued the use of such expressions as "the ratio of . . . equals the ratio of . . ."

If we now followed the usual texts on geometry we would proceed to the study of similar triangles. The teachers who believe algebra and geometry should be taught simultaneously can at this point devote a week to the study of proportions from its algebraic viewpoint, meaning as taught in the algebras. But when we examine the texts on algebra we find that the chapter on proportions is almost the same as in texts on geometry; namely, the usual propositions about interchanging means, the products of extremes, etc., leading up to some problems on similar triangles; and the only additional matter consists in solving some problems on the division of profits or the division of a line into parts having a certain ratio. Inasmuch as these sample problems can be solved just as well, if not even better, by the usual methods of other problems, it seems pertinent to discuss what the chapter on proportions in our algebras or ninth grade textbooks can profitably contain, for evidently the two chapters should not be mere duplicates of each other.

After defining the word ratio as the division of one number by another, or as a multiplier used in comparing two like quantities, we may begin the work with a problem such as: If 5 acres of land cost $325, what is the cost of 7 acres? This problem should be solved arithmetically (1 acre costs $65, etc.); and then after finding the answer we can call attention to the fact that the ratio of the cost equals the ratio of the acres. Even this fact is of no great interest, but we use the problem as a means of introducing the *word* proportion and introducing the idea that proportions can be used in any problem in which we are comparing two kinds of quantities. Also, from the statements "the number

of dollars is directly proportional to the number of acres" and "the number of dollars varies directly as the number of acres" we introduce two new phrases, *directly proportional to* and *varies directly as.* For the exercises that would next follow, the instructions would be:

1. Solve the problem by arithmetic.
2. Call the unknown number x, and write the proportion.
3. State what two kinds of quantities are being compared.
4. State in English the relation between these two kinds of quantities, once using the phrase "directly proportional to" and a second time using "varies directly as."

The next step is to introduce the idea of *inversely proportional to* and of *varies inversely as* by some problem on the work done by some men, or a problem about the arms and weights on a lever. Again the exercises would carry the same instructions as above so that the solution of the problem will be insignificant compared to the correct use of the new phrases. The following day we may assign a miscellaneous list of exercises in which the pupil must decide for himself whether the variation is direct or inverse or neither. Having then learned how to translate some information into a law of variation, we begin the converse problem: how shall we translate a given law of variation into numbers? For example, write as a proportion the statement that the number of bricks laid depends on the number of men working on the job. This is a difficult problem for the beginner, because he is accustomed to handling four numbers in any proportion. I believe it is worth while to keep this magic number 4 in his mind, and hence solve his difficulty by saying: Let us suppose that y men lay x bricks, and m men lay b bricks. Then $y/m = x/b$; that is, if the desired numbers are not present in the problem let x and y represent one of each kind, and any other two literal numbers for our second choice With this as a start we can lead to $y = kx$ and $y = k/x$ as an expression for the two laws of variation.[1]

Briefly, the chapter on proportion in the algebras should not aim to use proportions as a means of solving problems but rather as a means of increasing the pupils vocabulary with special reference to the phrases *proportional to* and *varies as.* Since the pupil

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[1]Although it may seem to be a digression, I call attention to the fact that just at this point in the algebra class the stage is most favorably set for introducing the notion of *variables*, because we are dealing with two kinds of quantities, and to each pumber chosen from the one there is a number from the other kind of quantity corresponding to it. Thus proportions can easily be used as an introduction to the subject of functional relations. The nearest approach to this method found in any text is in *Cajori and Odell's Elementary Algebra*, from which the writer has drawn many ideas. But in that text the transition from proportions to graphing is so abrupt that they actually seem out of place in the same chapter.

will get a more lasting impression and a better command of these phrases by studying them from as many points of view as possible it would seem worth while to study the algebraic and the geometric treatment together. The pupil can then understand his own words when he says "the segments on one side are proportional to the segments on the other" or "the altitudes vary inversely as the sides to which they are drawn."

NOTE ON PRIME NUMBERS.

By G. A. Miller,

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It is well known that about the middle of the preceding century a noted Russian mathematician, P. L. Tschebychef, proved important formulas relating to the number of the prime numbers in a given interval, which include the following: For every integer $x>6$ there is at least one prime number p such that

$$x/2 < p \leqq x-2.$$

when $x = 7$ the prime number p is 5 so that $p = x - 2$ in this special case. It is very easy to see that this is the only case when it is necessary to let $p = x - 2$.

If another such case would present itself x would again be odd and greater than 7. Hence $(x-1)/2$ would be an integer and there would be a prime number greater than this integer but not greater than $x - 3$ according to the given formula if x is replaced therein by $x - 1$. Hence this formula implies the following: For every integer $x > 7$ there is at least one prime p such that

$$x/2 < p \leqq x - 3.$$

The main object of this note is to warn the readers thereof not to adopt the former formula, which appears in various reliable works, including Landau's *Primzahlen*, volume 1, 1909, page 22. The present writer employed this formula several years ago in Miller, Blichfeldt, Dickson *Finite Groups*, 1916, page 167, where the latter formula would have been more useful. Hence this warning is the more earnest especially since the latter is such a direct consequence of the former and the notion of prime number is so very elementary. The note may also serve to illustrate the fact that obvious improvements are sometimes overlooked by the best authors.

AN EXPERIMENT IN THE USE OF THREE DIFFERENT METHODS OF TEACHING IN THE CLASS ROOM.

By George W. Hunter,

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The following series of experiments were performed by the writer under strictly class room conditions during the year 1916. At that time, he felt that there was need for some practical experiments in class room methods. The DeWitt Clinton High School, with its five thousand pupils, its system of nearly equal mental groups in the class room, and the large corps of teachers made an ideal setting for pedagogical experiments. As Chairman of the Department, the writer found it quite possible to arrange for such experiments as he wished, thanks to the cooperation of his principal, Francis H. J. Paul. He did not publish the experiments which follow, at the time, because he felt that they only could be used as guides for future methods and that the results were of only tentative value. The war came and interrupted the work. After the war the writer accepted a college position. The work thus interrupted can probaly bnever be completed. He has, therefore, thought that it might be worth while to publish the experiments even though the method used is necessarily crude and lacking control, and the conclusions reached must necessarily be tentative. They are edited simply in hopes that other teachers fortunately located as to opportunity may go on and add to the incomplete work thus begun.

McMurray[1] in his "Method of the Recitation" has shown that a modification of the class room didactics known as the "developmental method" is one type of teaching adapted to the mind of the young child. This method is particularly usable in connection with either the pure experiment or in the biological laboratory. It is an advance on the old-time laboratory method in that teachers and pupils may work out a given problem together. All the senses are employed and what is more important, the directive influence of the teacher is felt at all times, so that the recitation or laboratory work moves in a given direction toward a goal which the skillful teacher consciously keeps in sight. It is needless to say that from the standpoint of the hygiene of the teacher this method is wasteful of nervous energy.

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[1]McMurray, C. A., *Method of the Recitation.* Macmillan Co., 1903.

For the purpose of the set of experiments which follow, we have attempted to test the value of three methods only. The first we have called the *developmental method*. It was, in reality, the experimental method applied orally in the class room.

The second method used was the *lecture method*. The third method was the *text book method*. The text book has been relegated in science to a secondary place. It takes the place of supplementing the laboratory, and in adding to the fund of first hand information obtained through laboratory methods.

It has been pointed out by many writers on the place of science in education that it was not so much content as the scientific point of view that was of greatest value. In the method of science, the formal steps of the experiment are, as Dewey[2] points out, actually the steps that the mind takes in solving any problem. It is this analytic ability that we wish to see evident in the growing child. It is the science method that should inculcate a habit of reasoning. This greatest value of the sciences in our school courses seems to have been overlooked by Mayman[3] in his exhaustive series of experiments, for in no case does he attempt to differentiate between the child's ability to solve problems or "thought questions" as contrasted with pure memory work. He gives the two types of questions, but does not contrast two sets of figures for them. In the series which follow the writer has attempted this differentiation by means of thought questions which require the application of certain learned facts in relation with other stated facts.

It was, therefore, the province of the first series of experiments to test, by means of a series of class room experiments, the relative value of the lecture, book and developmental methods with reference to the immediate retention of memory work and of the relative value of the three methods in development of ability to answer thought questions, i. e., the development of power.

The Subjects.

The classes experimented with were boys of the first year of the DeWitt Clinton High School. In age records of several thousand students under consideration in the different series of tests, the median of the group was fifteen years and the range of age from twelve to eighteen years. In the series of tests with like groups, the age of the pupil answering the given

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[2]Dewey, John, *How We Think:* Heath, 1910.
[3]Mayman, J. E., *Teaching Elementary Science in Elementary Schools*, N. Y. Dept. of Education, Div. Research, Pub. 13, 1915.

questions was placed upon the paper of the individual pupil so that the age of the given group was easily obtained.

So far as possible the parallel group[4] was used in the series of tests. The method may be tried with some degree of accuracy in the DeWitt Clinton High School, because the incoming pupils are placed in classes according to the standing in the elementary school from which they come. This in itself is selective, as the ratings of "A," "B," "C," given by the teachers of the graduating class from which the boy comes are a mark of judgment on the part of the former teacher as well as the principal of the elementary school. A second factor of even more importance, however, artificially comes into play in the selection. It has been found, after several years of observation, that the pupils of best mental equipment as a group elect Latin. The DeWitt Clinton High School is the great college preparatory school of New York City. The best colleges usually still require Latin as an entrance unit. Hence the brighter boys choose this language.

A few years ago, the next brightest group of boys usually elected German, with French and Spanish following in the order named. Since the great European conflict, the choice of electives has changed. French and Spanish have gained while German has lost ground greatly, both in the number of pupils electing and in the quality of student electing. This statement was borne out by a study of the term sheets (or semi-yearly records) of the school.

While in making the following tests, the group of equal size, age, and equal mentality was not always possible, but wherever practical it was used.

Method and Material Used.

Throughout the first series of tests, which was begun in the spring of 1916, and was continued until the end of the term, the three methods, book, lecture and developmental, were tried exclusively Three teachers, other than myself, also tried out a series using the same three methods. During the spring term, February to June, 1917, other methods as well as the above were used, which are mentioned in a later series of experiments.

In using the *book method*, an actual text was used in every case, thus avoiding the criticism which Mayman himself cites, that the book method was not in his case an actual classroom

[4]See Bagley, W. C., "The Scientific Method in Educational Research," *N. S. Review*, 6, 1910, pp. 172-178.

condition, as he used mimeographed sheets. The pupils were told at the beginning of the test period that they were to study a certain chapter or selection from the chapter in the book, which assignment was immediately given out. They were in every case reminded that an experiment was in progress which was to attempt to find out which of three ways of learning a lesson was best for them. Quiet study was insisted upon, and no questions were given or answered. At the end of the study period (from 20 to 30 minutes) the books were collected and a short test was given, which test usually consisted of three questions, two memory and one a power question. The relative values of the two parts of the examination were not the same, but were reduced later to a percentage basis.

In the *lecture method*, the teacher attempted to follow accurately the material presented in the text book. Where illustrations occurred in the text, he either showed charts or made blackboard drawings. Where an experiment was described, the teacher either performed the experiment or, where that was not practical, he explained it. He did not permit asking or answering questions, but told the members of the class that he expected them to take notes of what they thought were the most important facts in the lesson. At the close of the lecture, the class at once went to work on the test, having first put aside their notes and notebooks.

The development method gave the most opportunity for work on the part of the pupils. In general the procedure was as follows:

The lesson was introduced usually in the form of a problem, which it was understood was to be jointly discussed by both pupils and the teacher. So far as possible, freedom of discussion was encouraged, but the teacher always attempted to keep the discussion within the confines of a set problem. Wherever, possible, the concrete experience of the student was made to play a part; while the teacher formulated the questions, he tried to always "develop" the topic under discussion in such a way that he built upon the previous experience of the pupil. Where a gap had to be bridged, then telling was a part of the lesson. But in no case was there any formal lecturing. The teacher tried so far as possible to keep up a rather rapid fire of questions, which were directed to all members of the class, the duller as well as the more alert pupils receiving opportunity to answer the questions. But as invariably happens in the classroom, the mentally active pupil does most of the work. This

method of the three was most prodigal of the activity of the teacher. Not only must the questions always be directed along the proper channels, but the pupils who wander from the problem in mind must be kept on the track. In addition, the teacher must be quick to sense the dangers of too long a jump from the known residue in the child's mind to the new material given. Always he must be striving to produce a reaction on the part of the members of the class, which results in the thought process, and not in the mere guess. The pace must never lag, and yet the children must be given time to assimilate the material given. (See McMurray[6].) This lesson was like the other two in the series, and was timed so as to give the test at the end of the period. A retention examination was given after one week's time in the first experimental series of tests given. These results will be cited at later points.

Data blanks were employed in the tests so that laboratory conditions might prevail. In order that we might have control data certain questions were invariably asked so that the teacher might know when correcting the test-papers, whether any outside factors were to be considered. Most important of these are the questions of fatigue, and of weather conditions. (See Parez,[6] Lay[7], Dexter[8] [9].) In order that this data be in tabular form the following blank was filled out by the teacher making the test at the time of the test:

Data Blanks for Tests—DeWitt Clinton High School.

Method used.................Date.................Period.................Biol.......................
Number of boys...Average age...................................
Weather...
Light in room...
Air in room..
Temperature..
Humidity...

	Per I.	Per II.	Per III.	Per IV.	Per V.
Previous work of class					

Time allowed for learning
Time allowed for Examination
Interest for Teacher
Interest for Class
Fatigue for Teacher
Fatigue for Class
Remarks

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[6]McMurray, *Conflicting Problems in Teaching and How to Adjust Them*. The Macmillan Co., 1916.
[6]Parez, C. C. "The Mental Fatigue in Germany," Special Reports on Educational subjects (England), Vol. 9, page 540.
[7]Lay, W. A., *Experimental Padagogik* (Leipsig). Page 40. 1908.
[8]Dexter, E. G., "Conduct and the Weather," *Psych. Review*, Vol. 11, page 44. 1899.
[9]Dexter, E. G., "The Child and the Weather," *Ped. Sem.*, Vol. 98, 512-522.

The Test Questions.

In making out the test questions indicated, two types of questions were used. In one type (memory type) facts which had been mentioned or read about were demanded by recall. Sometimes associative memory was called for as well. Great care was used to call for facts or principles which were brought out by the given lesson, and not by means of some previous lesson.

In the second type of questions the ability to interpret relations was demanded. Frequently the question was formulated as a concrete type of problem and in difficult questions of this type an abstraction was attempted. Great care was used so that guessing would not gain a reward and an attempt was made to differentiate rather exactly between the memory type and the power type of question.

In general the following procedure was used in testing a given class. The boys of each group were told at the beginning of a series of tests that they were to be examined at the end of each lesson with the view to finding out which was the best way for them to learn a given lesson.

Each day they were pitted, as a class, against some other class or classes and were encouraged to do as well as possible so as to make their own score high. They were asked to be individually honest and careful both in their methods of study and in their reproduction of the lesson.

At the close of a given lesson by any of the three methods, sheets of paper were passed from the front of the room to the pupils in the rear. They were asked to quickly but neatly write their names, ages, class number, date and type of lesson given. Then the questions were dictated orally, and the pupils asked to write them at the head of their papers. The questions were repeated once slowly. Difficult words were spelled. This oral method of giving the questions was used because it permitted the teacher to see the class at all times, thus effectually preventing any attempts at cheating which might occur at this time. Care was taken to allow pupils with defective hearing or vision to sit well forward in the room. At a given signal the pupils began work.

During the period, while the pupils wrote answers, the teacher took careful notes of the conditions of the pupils at the time of writing the tests. All signs of fatigue, inattention, or lack of interest, as well as their opposites were noted. When the bell rang for the completion of the period, the papers were collected

rapidly by pupils chosen for this purpose. After collection the papers were put aside until the completion of the series.

The scoring of the papers, which was done after an interval and so far as possible under uniform conditions, was made on a basis usually of 50 points when three questions were given, but all comparisons were worked out on a percentage basis. If three questions were given, the one power question was counted as much weight as the two memory questions. If questions were answered partly right and partly wrong, proportionate credit was given. Each answer was rated individually correct or partially correct, incorrect, or partially incorrect, the underlying fact in the memory question and thought in the power question being the basis of comparison. Each paper when finished received the sum of the total questions, multiplied by two, so as to bring it to a per centum basis.

The Experiments.

Each individual experiment of the first series consisted of a certain number of tests given by three different methods to three different classes. The three methods tried were: Text-book, lecture and developmental. The summary of the results of these methods was given by means of a table and the results are also shown graphically, the percentage attainments (number of pupils and per cent per question correct) were shown by means of graphs. Each complete experiment should therefore contain:

(A) Discussion, (B) Table (C) Tentative Conclusion.

My first series of twelve tests, would (according to the method of Mayman) make four distinct experiments. According to my own method, the series of three tests as given by Mayman would not in reality make a single experiment because of the lack of the control element in the series. If for example classes A, B and C are given, on the same day, test I, by methods 1, 2 and 3, then we have, in spite of the assumption that we are dealing with equal groups, no surety that classes B and C would react to method 1 in exactly the same way as would class A. In other words, the problem is much more complicated in its working out than Mayman has assumed. In any experiment carried on with human species, the laboratory method is only difficult to carry out with exactitude because of the numberless uncontrolled factors which must of necessity, enter into the handling of the experiment. The results we would obtain are imperfect

and inexact. But we may, at least attempt to carry out our experiments in the spirit of the scientific investigator.

To do this with the problem as outlined it seemed to the writer that we must give the three different methods to the same class on three successive days with as nearly the same type of lesson material and the same general type of questions. To do this, we must then plan for three successive days' work with the three equal groups. The plan as worked out may be diagramatically shown as follows:

Class	Monday	Tuesday	Wednesday
A	Method 1	Method 2	Method 3
B	Method 2	Method 3	Method 1
C	Method 3	Method 1	Method 2

In such a series the conclusions reached would, it seemed to me, be worth much more than in the experiments as planned and described by Mayman, where the Monday series constitutes one experiment, the Tuesday series a second experiment, and the Wednesday series a third experiment.

In attempting to test recall the problem is obviously more difficult. The plan which seemed best to the writer was to take elements from all three of the examinations for the recall test series; the series to be given at the beginning of each of the three periods of a given day. This plan as well as a recall test series of identical examination questions was tried out also.

It must be remembered that even with the experiments as planned from a scientist's point of view there are still many points of objection. It is necessary for example, for us to interpret certain findings in the light of weather conditions, fatigue of class, personality of teacher, etc. The results, then of any series of tests, as has been pointed out by Whipple[10] is at best only an indication and not a hard and fast result. If the series which follow are interpreted in this light, some value may come in the application of such methods as seem proved successful by experiment in the classroom.

Experiment I—Test Series 1 to 9 Inclusive.

The classes used in this were first term classes of supposedly nearly equal mental calibre. I say supposedly because subsequent tests showed a decided difference in the mentality of the groups. The classes had been in charge of another biology teacher during the term, and had been by him put through an

[10] *Manual of Mental and Physical Tests*, Guy Montrose Whipple. Macmillan, 1907.

initial series of tests. I took the classes during the last two weeks of January, 1916, and it was at this time that the following record was made. The classes are known respectively as 107 122 and 147, and represent average Latin, German and French sections respectively. The series was begun on Monday, January 17, 1916. The material covered by the series of tests was selected from Ritchie's *Primer of Sanitation*, and is found in the three chapters of about equal ease of comprehension on "Malaria," "The Relation of Mosquitos to Yellow Fever and Malaria," and on "Other Protozoan Diseases." This little book is extremely well written; has ample but simple illustrations, and is brought down to the comprehension of the children through the elimination of all unnecessary scientific terms, and by a charmingly direct diction. It was to the boys a very appealing book, and had the additional value of being new to the classes which used it for the first time in the test. In working out the lecture and development lessons, I was careful to go through the assigned book lesson, and pick out only those topics which were covered by the paragraphs to be given out in the lesson. In every case an attempt was made to have the series as nearly equally weighed as possible in subject matter and the test questions were also prepared with the same end in view, a nearly equal number of points being expected in each examination.

The problem treated on Monday, January 17, was "*Malaria and its Relation to the Malarial Mosquito.*" The following was the test:

1. (A) What causes Malaria?
   (B) What part of the body is attacked by the disease?
2. Name three ways to prevent Malaria.
3. Compare Malaria with Typhoid Fever, telling one respect in which the diseases are alike, and two in which they differ. Give reasons for your answer.

It will be noted that question 1 is of the pure memory type, asking for specific information. Question 2 is of the same type. Question 3, however, which was weighted 30 as against 20 for the other two questions, required comparison and generalization. The study of typhoid fever had been made the week previous, and was thus supposed to be part of the equipment of the pupils.

Developmental Method.

This lesson was taught to class 107, 30 pupils, the first period of the day by the "Developmental Method." The day was

bright, clear and cold, room temperature 70°, humidity low. The boys at the beginning of the test were taken into confidence, and asked to cooperate in the test series. The idea of rivalry was brought out and they were pitted against the two other classes in the series. I spent 30 minutes in development of the lesson. The class acted as if it was interested, was responsive, although volunteer recitations were in order as I did not know the members of the class well.

During the test the entire class gave evidence of seriousness, acting as if interested in making a good record. The bell found most of the class still at work, the test lasting exactly ten minutes.

Lecture Method.

The lecture method was used with class 122. The weather conditions unchanged; the room had become a little overheated (74), so the windows were opened for a moment. The class, which was larger than the previous one, 35 pupils, was inclined to be disorderly. They were told of the experimental series and after being asked to help and give as good a record for themselves as possible, they at once settled down quietly. At times during the lecture, some members were inclined to ask questions, but refrained after a word from the teacher. The lesson lasted 30 minutes. During the test most of the boys worked hard. A few cases of wandering attention were observed, and several attempts to copy were noted. These, it might be said, were not carried out. The test occupied just ten minutes.

The Book Method.

Class 147 contained only 25 pupils, having lost several through illness. Weather conditions were as above; room temperature 70. The class was a little late in coming to the room, and lost about three minutes, having been sent to another room by mistake. After the experiment was explained to the class, they were urged to make the best possible record. The books were given out and the lesson assigned orally. No introduction as to the importance of any special part of the lesson was given, nor was any direction given as to how to study. The period was in no sense a directed or supervised study period. The boys went directly to work, and worked with interest and seeming concentration. There were two slight interruptions caused by visitors. Not all boys utilized the entire period of study on

the lesson, but could be seen turning over the pages to look at the illustrations or reading ahead, or in other parts of the book. The study period which was shortened to 27 minutes was not utilized to the end by more than a third of the class.

The test was taken less seriously than by the preceding classes, several of the boys finished before the 10 minutes were up. There were a few attempts to copy, but they consisted of idle glancing rather than deliberately planned efforts.

In marking the test papers some weeks later, the teacher had forgotten where he laid his emphasis in the lecture or developmental lesson, but decided to mark the two memory questions ten each, five on each point in 1, and ten for the three parts in 2. In the power questions ten each was given each of the three points in the question, each of these steps requiring a separate judgment or comparison. This made the total for the examination 50 instead of 100. The percentage basis was gained by multiplying by two.

Memory Questions—Total Points Possible 20.

	0	5	10	15	20	Total
Class 107 Development	0	1	5	9	15	30
Class 147 Text book	0	0	10	10	5	25
Class 122 Lecture	1	1	5	8	20	36

Power Questions—Total Points Possible 30.

	0	5	10	15	20	25	30	
Class 107 Development	4	3	7	6	6	2	1	30
Class 147 Text book	15	4	2	1	2	1		25
Class 122 Lecture	13	16	4	1	1			35

Total Examination—Points Possible 50.

	0	5	10	15	20	25	30	35	40	45	50	
Class 107 Development	0	0	0	3	6	6	5	3	4	2	1	30
Class 147 Text book	0	0	6	8	5	1	2	3	0	0	0	25
Class 122 Lecture	1	2	1	5	13	8	4	0	1	0	0	35

In comparing the attainments of the three methods on the same lesson a careful study of the figures on page 885 will be necessary.

In the first series of three both in the memory and power group, class 107 with the developmental method far surpasses the book method which comes at the foot of the test, and almost as badly beats the lecture method on the power question. On pure memory, however, the lecture method holds its own. In actual attainment we have, the developmental method scoring first each time, as a glance at the percentage score shows.

Experiment I—Second Series.

Tuesday, January 18, 1916. Lesson problem: *The life history of the mosquito as related to malaria and yellow fever with especial reference to the life history of the insects. Methods of extermination in relation to work of civic authorities.*

Developmental Method.

Class 147 came the first morning period, 9:20 a. m. The day was like the previous one, clear, cold, little humidity; temperature of room 70; air fairly good. The lesson was taught by the developmental method. Boys seemed interested, although not participating enthusiastically in the work. A brief review brought out the fact that many were careless in interpretation of facts built on the lesson of yesterday (they learned by the book method yesterday). The lesson was finished in just 30 minutes. As the class was late in coming in, the teacher allowed three minutes over the period to finish the test. The boys went to work in a businesslike manner and worked entirely through the period; six of them made use of the extra three minutes given them in order to finish.

Lecture Method.

Class 107, time 12:15, day still clear, cold, little humidity, temperature 71, air fairly good, class a little late in beginning so had to run over two minutes in order to finish lecture. Allowed 30 minutes: Allowed two minutes over on test so as to give even ten minutes. Boys took up test in a businesslike manner, and worked until bell rang. Some used the extra two minutes; some tendency toward talking during the test.

Book Method.

Class 122, time 1:45 p. m., conditions as in last period except that change of room gave us a much darker room on court side

into which the sunlight did not enter. The class was rather disorderly and the room looked unkempt and dirty, a great contrast to the bright and sunny one in which the other test was given. The books were given out and the boys settled down slowly to the work of reading the lesson. It was evident that there was some misunderstanding as to the meaning of the study period. Two asked, "Is that chapter all the assignment?" The charts and demonstration material were called to the attention of the class, but except for the glass box containing the mounted specimens showing development of mosquitos, little attention was given to it, and none so far as I could see, to the charts. Artificial light was put on before the period was half gone. But most of the boys were wasting time before the period was over. The test period was not utilized to its full extent by several boys. There was some inclination to copy, but on the whole, the class was busy until the end of the period.

The questions asked in this series were as follows:

Memory Test.

(1) Describe the life history of a named mosquito, giving stages; tell when each of these stages may be formed and give the usual duration of a mosquito's life.

(2) Compare the Anopheles and Culex mosquito, giving two ways in which you could tell them apart.

Power Test.

(3) Is malaria a country or a city disease? Give two reasons for your answer.

It is to be noted that the power question in this test was not as hard as in the previous test, while the memory questions asked for more points to be remembered. These facts showed up in the examination ratings; these papers, like the others were rated after a lapse of several weeks.

The most noticeable contrast as compared with the first series of tests was the fact that the developmental method did not show up as well as either the lecture or book method on

Series 2—Experiment 1.
Memory Questions—Total Possible 20.

	0	5	10	15	20	
Class 147 Development	0	1	6	9	8	24
Class 107 Lecture			3	7	16	26
Class 122 Book		1	6	19	12	38

Power Questions—Total Possible 30.

	0	5	10	15	20	25	30	
Class 147 Development	4		1	9		3	7	24
Class 107 Lecture				5	14	2	5	26
Class 122 Book	5	3	3	20	4		3	38

Total Examination—Points Possible 50.

	0	5	10	15	20	25	30	35	40	45	50	
Class 147 Development			2	2	1	5	4	1	2	2	5	26
Class 107 Lecture						1	2	7	11	2	3	26
Class 122 Book		1	1	3	3	3	12	11	1	1	2	38

the memory questions. On the other hand, it still held first place in the power question and was followed by lecture method, the text book method coming out in third place.

In view of what we had found in the first series it was rather disconcerting to find that the development method was so low in places. We began to suspect that class 147 was not an equal group with the other classes.

Experiment I—Third Series of Tests.

Wednesday, January 19, 1916. The day was sunny, dry and cold, thus completing the test series under practically equal weather conditions. The lesson problem for the third series was *"Other diseases caused by protozoan parasites, with especial emphasis on rabies,"* the assignment being three fourths devoted to the latter topic.

Text Book Method.

The series opened at 9:20 a. m. in a bright sunny room; temperature 71, shades pulled partly down to keep out the sun. Class 107 was late in getting to the room so that the class lost four minutes before getting the books out and settling down to work. The boys began work with vigor and continued at work until the signal to stop work was given. Several boys had not completely read the assignment, and showed this by exclamations. The test was given in the usual manner, the

boys working rapidly and with seeming determination and interest.

Developmental Method.

Second period, 9:45 a. m. Room hot but cooled off by opening windows, so that temperature was 70, during the test, Class 122 was very demonstrative during the lesson, much volunteer answering, and much raising of hands. Many tried to answer, but about one third of the class were inactive mentally. The teacher failed to arouse them because he did not know them well enough. Felt fatigued when the lesson was over because of rapid pace. Test was given after 30 minute lesson in usual manner; class was active until end of test; little or no attempt to copy noted.

Lecture Method.

Class 147 followed at 10:30 a. m., room conditions as in last period, aired room for three minutes while classes were passing so that temperature dropped to 69°, but it soon went to above 70°. The class was interested and some boys attempted interruptions to ask questions. The test was given after 30 minutes' lecture in the usual manner. Boys worked hard up to the end of the period. The questions given were:

Memory Questions.

1. Name 5 diseases probably caused by protozoans, and tell how any one is contracted.
2. Why are mild cases of measles or scarlet fever often dangerous?

Power Questions.

3. Rabies or hydrophobia may be stamped off the face of the earth. What steps would be necessary to do this and why?

It will be noted that question 2 has some elements of the power question in it as well as question 3. This was found to be much harder than question 3 in spite of the fact that careful reading or listening would have recalled this rather minor point. The tables which follow show that this examination was, however, not so hard for the classes as the previous ones; possibly because of the interest exhibited in rabies.

Memory Questions—Possible Total 20.

	0	5	10	15	20	
Class 107 Text book		5	3	7	16	26
Class 122 Development			5	5	25	35
Class 147 Lecture			7	9	14	30

Power Questions—Possible Total 30.

	0	5	10	15	20	26	30	
Class 107 Text book				5	14	2	5	26
Class 122 Development	3	1		2	13	3	13	35
Class 147 Lecture		2	4	6	6	5	6	30

Total Examination—Possible Total 50.

	0	5	10	15	20	25	30	35	40	45	50	
Class 107 Text book						1	2	7	11	2	3	26
Class 122 Development			1	1	1	2	1	4	10	2	13	35
Class 147 Lecture				1	3	2	4	5	6	4	4	30

In this series of tests the developmental method came out first in all the above tables. With the lecture method a rather close second, the text book method again lagged though not so much as in the first series. If we now turn the above tables into percentage tables we get the following results. Following these are the graphic results.

Class 147 Textbook	Total 37.84 Memory 70.20 Power 16.26	Class 147 Development	Total 55.91 Memory 74.16 Power 57.63	Class 147 Lecture	Total 71.10 Memory 80.34 Power 64.94
Class 107 Development	Total 58.34 Memory 81.54 Power 43.45	Class 107 Lecture	Total 62.07 Memory 80.68 Power 50.00	Class 107 Textbook	Total 77.30 Memory 86.92 Power 71.23
Class 122 Lecture	Total 40.40 Memory 80.28 Power 13.90	Class 122 Text-book	Total 59.13 Memory 78.81 Power 46.05	Class 122 Development	Total 79.60 Memory 88.28 Power 73.81
	1, 17, 16 Development 3 first places		1, 18, 16 Lecture 2 first Development 1 first		1, 19, 16 Development 3 firsts

Total Development Method, 7 firsts.
Total Lecture Method, 2 firsts.
Total Text book Method, 0 firsts.

(To be continued.)

RELATIONS BETWEEN LAND AND SEA ON THE NORTHEASTERN COAST OF LABRADOR.

To the physical geography of a region still little known scientifically, A. P. Coleman makes a welcome contribution in "Northeastern Part of Labrador, and New Quebec" (*Geol. Survey of Canada Memoir* 124, Ottawa, 1921). The most impressive feature of the region is the relation between sea and land. The coast is one of the most bold and rugged in the world. Great promontories with nearly vertical cliffs 1,000 to 2,000 feet in height run out between an intricacy of deep fiords, and deep and narrow channels separate the fringing islands from one another and the mainland. On this proverbially stormy coast wave action is profound; it is "the most important destructive work now going on in Labrador, since the small glaciers are doing little, the clear water rivers are cutting but slowly, and general weathering must be going on very deliberately in a region where snow lies for eight or nine months and the summers are cool and comparatively dry." During the months of July, August and September, when the fishing fleets frequent the shores, northeasterly winds of a monsoonal character are dominant. Gales are common and violent, especially in September. During their occurrence waves at exposed places pile up to more than fifty feet above sea level and the spray is hurled a hundred feet up the sides of the cliffs. The shore forms show a rapid headway being made by marine erosion. On the sharp cliff faces there are characteristic examples of hanging remnants of glaciated valleys, and there is no suggestion of recent faulting. The coast appears straight on small-scale maps, but in detail the seaward front trends in all directions.

Along most of the coast the tidal range is not great, but off Cape Chidley, the northern extremity, it amounts to from 30 to 50 feet in the spring tides whose force and magnitude are not surpassed even by the famous tides of Fundy. In places tidal anomalies have been observed; thus in Nachvak fiord early in August, 1916, there was a difference of two feet in the height of the two diurnal tides.

The third great dynamic force of the sea, the ocean current, also has a profound influence on this coast. The ice-laden Labrador Current is the main stream, though there appear also to be minor currents. Occasionally spruce wood is drifted into the northernmost fiords, swept into the main current apparently by northeasterly currents from Ungava Bay. The prevalence of on-shore winds means that the summers are cool and foggy: "The occasional southwest winds felt almost sultry in contrast with the ice breath from the waters of the Arctic current." The easterly winds, also, drift floe ice into the fiords, thus further contributing to the lowering of temperature. In connection with the comparatively rare westerly winds of summer a chinook effect is worth noting. The deeper north and south valleys have a comparatively warm, dry climate. In late August the grassy floor of one such valley opening into Nachvak fiord was sere and yellow, and above the valley flat on the eastern side berries ripened much earlier than at Hebron 60 miles farther south.—[*Geographical Review*.

THE TEMPERATURE AND PRECIPITATION OF ALBERTA, SASKATCHEWAN, AND MANITOBA.

The climatic limit to cultivation is perhaps the most important element to be considered in the development of western Canada's unsettled lands, and it is highly desirable that temperature and rainfall data in great detail be made available. This the Meterological Service of Canada is doing in a series which began appropriately with British Columbia in 1915 (*Geogr. Rev.*, Vol. 1, 1916, p. 228), and which is now followed by "The

Temperature and Precipitation of Alberta, Saskatchewan and Manitoba" (Ottawa, 1920), by A. J. Connor, Climatologist. Tables and maps constitute the body of this publication, most of the interpretation and application being left to others. The tables show for each year the dates of first and last frost at 204 stations and the monthly rainfall at 295 stations, arranged by watersheds; and the monthly means and extremes of temperature, rainfall, and snowfall by decades at the 38 stations with adequate records. The 16 maps (on large township base map, scale about 40 miles to an inch) show in great detail the monthly mean maximum and minimum temperatures and the April-May, June-July, August-September, and mean annual precipitation. Isotherms are given for every 2° F. and isohyets for every 1 or 2 inches.

The coldest district is near Hudson Bay, where in January the mean daily minimum temperature is below —32° F. and the maximum below —15° and in July below 40° and 66°, respectively. In summer, however, the Rocky Mountains are colder. The hilly region west of the large Manitoba lakes is cold, the mean daily minimum and maximum being in January below —18° and 3° F. and in July below 48° and 74°, respectively. The hills and dissected high plains not far east of the Rockies are also cold being somewhat warmer in winter and colder in summer (higher altiude) than the eastern hills. Along the border of western central North Dakota the mean minima in January are as low as —10° F., where the cold waves seem to have their freest sweep southward. The warmest district is in southern Alberta. The highest winter temperatures (January mean daily minimum below 4°, maximum below 30°) occur near the mountains, where the chinook blows most often, eating the snow off the cattle ranges; and the highest summer temperatures (July mean minimum about 52° to 54°, maximum about 78° to 82°) are experienced farther east, about Medicine Hat and on the plains of southern Saskatchewan and Manitoba.

The average annual precipitation ranges from about 10 to 20 inches, 15 to 25 per cent of which falls in April-May, 30 to 40 per cent in June-July, 20 to 25 per cent in August-September, and only about 30 per cent in the colder half year. The April-May rainfall is greater than that of August-September in the west and less in the east, possibly because of the coldness of the eastern lakes in spring. The belts of hills (generally forested) are marked by rainfalls of 5 to 10 inches more than those of the neighboring lowlands, and in the Rockies of southwestern Alberta the excess is 20 inches (total, 31 inches). The southeast is in general the wettest, and the far northwest the driest.

Within the regions generally favorable to agriculture so far as temperature is concerned, the local uncertainties of rainfall are of prime importance. On this account Mr. Connor suggests the establishment of rainfall stations several years before settlement, especially in the climatically little-known region north of the 53rd parallel.—[*Geographical Review.*

A STAR LARGER THAN BETELGEUSE.

The enormous size of Betelgeuse, as revealed by interferometer measurements at Mount Wilson, was a topic of widespread popular interest a few months ago. News now comes from the same observatory that Antares, the well-known first-magnitude star in the Scorpion, is probably even bigger. Its angular diameter, as measured with the interferometer, comes out 0.039 second, thus greatly exceeding Russell's predicted value of 0.028 second. There is some question as to the parallax. If it is assumed that Antares belongs to the Scorpion group, the resulting value of the parallax is 0.0085 sec., and the diameter 430,000,000 miles. If, however, we give the same weight to this value and to the mean of the measured parallaxes, we find 0.013 sec., and a diameter of 280,000,000 miles. Either value is greater than that obtained for Betelgeuse; viz., 218,000,000 miles.—[*Scientific American.*

NEW ENGLAND ASSOCIATION OF CHEMISTRY TEACHERS

ANNOUNCEMENT OF PROPOSED MEETINGS AND TRIPS

DECEMBER SECOND AND THIRD

December 2 and 3 there will be held a joint meeting of the Eastern Association of Physics Teachers, the General Science Club, and other science teachers. The New England Association of Chemistry Teachers functions with other science organizations, as the Science Section of the New England Association of Colleges and Secondary Schools. There will be given a dinner and meetings in Boston. President Angell of Yale and other distinguished speakers will give addresses at the dinner, Friday evening, and Dr. Morris Meister of Columbia and others at the Science meeting Saturday, a. m. All interested in Science are invited. Programs, giving further details, will be sent later.

DECEMBER TENTH

December 10 the Second Regional meeting of the Western Division of the New England Association of Chemistry Teachers will convene at Meriden. A tentative program includes a trip through the International Plating Company, in the morning, starting from the Meriden station of the N. Y., N. H. and H. R. R., at 10:00 a. m. Lunch will be served and in the afternoon a session will be held at the Meriden High School. The afternoon session includes a talk by Mr. Aurand, Chemist at the Wallace Plating Company, Wallingford.

Newly appointed committees will report and plans for the future activities of the division will be formulated.

Chairman Leslie O. Johnson of the New Haven High School announces that an attempt will be made to increase the Connecticut membership from fifty to seventy-five before Christmas. Further bulletins, giving information on the Connecticut activities, will be issued and the complete program of the Meriden meeting sent as soon as practicable.

It will be remembered that Western Massachusetts is functioning with Connecticut, as the Western Division of this Association.

MISCELLANEOUS NOTICES

1. The Reconstruction Drive of 1921 has yielded more than 200 applications for membership. The Treasurer informs the Secretary that not all who have applied for membership have sent their check for dues. Will members in arrears please send their dues in promptly and so help the association in the prosecution of its work.
2. Please notify the Secretary of any change in address.
3. Apply to your Division Chairman or to the Secretary for application blanks, sample or duplicate reports, etc. Notify them of any prospective candidates for membership.
4. Reports of Brown and Yale meetings are delayed, but will probably be sent out in December.

S. WALTER HOYT, Secretary,
20 Stone Road, Belmont, Mass.

PROBLEM DEPARTMENT.

CONDUCTED BY J. A. NYBERG,
Hyde Park High School, Chicago.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and solve problems here proposed. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The Editor of the department desires to serve its readers by making it interesting and helpful to them. If you have any suggestion to make, mail it to him. Address all communications to J. A. Nyberg, 1039 E. Marquette Road, Chicago.

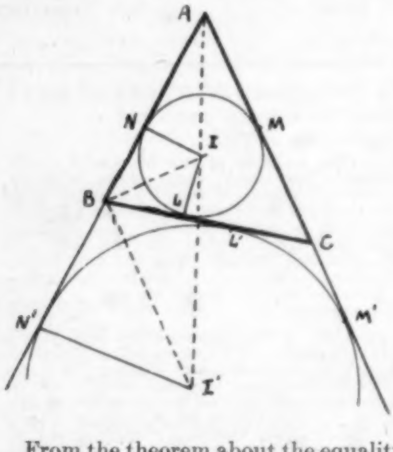
SOLUTION OF PROBLEMS.

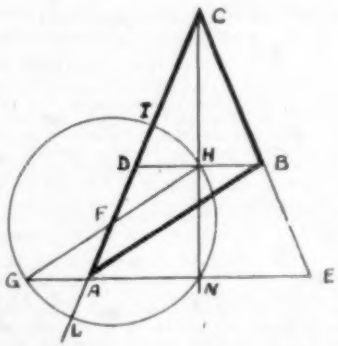
706. *Proposed by numerous contributors.*

Is there any simple proof for the formula $S^2 = s(s-a)(s-b)(s-c)$ for the area of a triangle in terms of its sides which does not involve trigonometry nor the complicated algebraic manipulations which are unavoidable when we multiply the base by the altitude as in the text books?

I. *Solution by F. Howard, San Antonio, Texas.*

In the figure, ABC is the given triangle, I is the center of the inscribed circle, I′ the center of an escribed circle (the intersection point of the bisectors of the external angles at B and C), L, M, and N are the points of tangency of the inscribed circle, and L′, M′, and N′ are the points of tangency of the escribed circle, r is the radius of the inscribed circle, and r' the radius of the escribed.





From the theorem about the equality of tangents from a point to a circle, we get $AN' = s$, $AN = s-a$, $BL = s-b$, $BN' = s-c$. (It is also true that $CL = s-c$, but the other relation is more useful). From the similar triangles AN′I′ and ANI, $I'N'/IN = AN'/AN$ or $rs = r'(s-a)$. From the similar triangles BN′I′ and BLI, $I'N'/BL = BN'/IL$ or $rr'(s-b)(s-c)$.

The area of the triangle ABC is $S = rs$, or $S^2 = (rs)(rs)$. Replacing one factor by $r'(s-a)$, it becomes $S^2 = rsr'(s-a)$. Now replace the rr' by $(s-b)(s-c)$, getting $S^2 = s(s-a)(s-b)(s-c)$.

Similarly solved with slight variations by *J. W. Clawson, Ursinus College, Pennsylvania,* and *T. E. N. Eaton, Redlands H. S., California.*

II. *Solution by C. E. Githens, Wheeling, West Virginia.*

In the figure, ABC is the given triangle, CB is prolonged so that CE = CA, CN ⊥ AE, BD ∥ AE, F is the midpoint of DA, and F is the center of a circle of which FN is the radius. The circle will pass through H the

midpoint of DB, and G is its other intersection with AE. I and L are the intersections of the circle with CA.

CF = 1/2(AC+BC), and FL = FH = 1/2AB, so that CL = 1/2(AC+BC+AB) = s.

DL = AI = s−BC, CI = s−AB, and AL = s−AC.

CN×AN = Area ACE, HN×AN = Area = ABE. Subtracting:

AN(CN−HN) = AN×CH = Area ACB. (1)

CH×DH = Area CDB, HN×DH = Area ADB. Adding:

DH(CH+HN) = GA×CN = Area ACB. (2)

Multiplying equations (1) and (2),

$$GA\times AN\times GH\times CN = (\text{Area } ACB)^2 = S^2.$$

But CN×CH = GL×CI and GA×AN = AL×AI = AL×DL

S^2 = CL×CI×AL×DL = $s(s-a)(s-b)(s-c)$.

Mr. Githens adds that he has copied this solution from one of his old scrap books on mathematics and can not recall whether this solution is original with him or not. It is certainly a very unusual and very interesting one. The proof that CL is half the perimeter of the given triangle is a splendid exercise in elementary geometry.

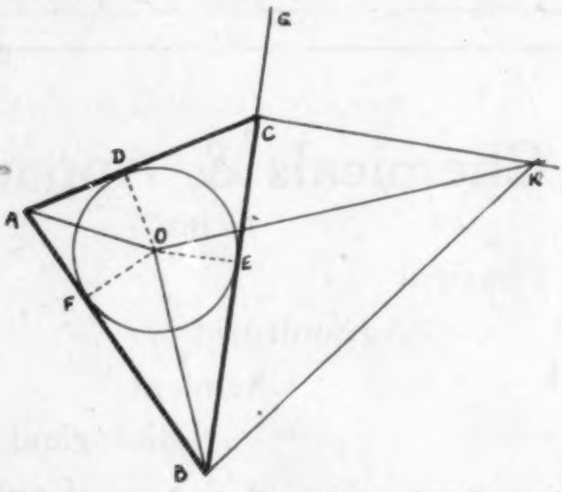
III. *Solution by F. A. Cadwell, St. Paul, Minnesota.*

In the figure, CK is drawn perpendicular to BC, and OK ⊥ BO, and CG = AD; then as usual, BG = s, BE = $s-b$, EC = $s-c$, CG = $s-a$. Since $S^2 = r^2s^2$, the formula will be proved if we prove that

$$r^2s^2 = s\times BE\times EC\times CG.$$

∠BOK = 90° = ∠BCK. Hence BOCK can be inscribed in a circle. Then ∠BOC+∠BKC = 180° and ∠BOE+∠COE+∠AOD = 180°, so that ∠BKC = ∠AOD. Hence triangles AOD and BKC are similar, and also triangles EOJ and CKJ. The first leads to AD/BC = OD/CK or CG/BC = OE/CK; the second leads to OE/CK = EJ/CJ. Hence CG/BC = EJ/CJ.

Heron's own.



Adding the numerators to the denominators, inverting, and then replacing CG+BC by s, and EJ+CJ by EC, gives

$$\frac{s}{CG} = \frac{EC}{EJ}$$

Multiply the numerator and denominator of the left member by s, and of the right member by BE, gives

$$\frac{s^2}{s\times CG} = \frac{BE\times EC}{BE\times EJ}.$$

But BE×EJ = OE^2; hence, clearing, $s^2\times OE^2 = s\times BE\times EC\times CG$.

Q. E. D.

Back numbers of School Science, School Mathematics, and School Science and Mathematics may be had for 30 cents a single copy. The Mathematical Supplements for 15 cents a copy.

In sets the prices are, postpaid:

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School Science, Vol. IV, three numbers	.75
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School Science and Mathematics, Vols. XVIII, XIX and XX each	2.50

Mr. Cadwell writes that this solution is found in "*Geometrie Practique des Grecs*" *Vincent*, (*Notices et Extraits Des Manuscrits de la Bibliotheque Imperiale et autres Bibliotheques*, vol. 19, page 287). The editor believes that some very valuable material has been brought to light by these solutions, and that henceforth more of us will feel inclined not only to use this theorem in our classes but also to prove it.

707. *Proposed by Daniel Kreth, Wellman, Iowa.*

Construct triangle ABC, given the base a, the difference $b-c$ of the sides, and the difference $\angle B - \angle C$ of the angles at the base.

Solution by T. E. N. Eaton, Redlands H. S., California.

Call B the vertex of the given difference $\angle B - \angle C$. Bisect this given difference and on one side of the angle measure BC $= a$. With C as a center, and a radius $b-c$ draw an arc cutting the bisector at R. Extend CR to A making $\angle ARB = \angle ABR$.

Proof: $\angle ARB = \angle C + 1/2(\angle B - \angle C) = 1/2(\angle B + \angle C)$, which shows that $\angle A = 180 - 2\angle ARB = 180 - \angle B - \angle C$. Also CR $=$ CA $-$ BA $= b-c$.

Similarly solved by *F. A. Cadwell, C. E. Githens, Michael Goldberg, Philadelphia, F. Howard*, and *E. Tabor, Upper Lake, California.* Although the arc may cut the bisector of the angle at two points, there are not two solutions for the two resulting triangles formed are congruent

708. *Proposed by Norman Anning, Ann Arbor, Michigan.*

Given $f(x) = x^4+x^3+x^2+x+1$, factor $f(x^2)$, $f(x^3)$, $f(x^4)$.

Solution by Michael Goldberg, Philadelphia, Pa.

$$f(x) = x^4+x^3+x^2+x+1 = (x^5-1)/(x-1); \quad f(-x) = x^4-x^3+x^2-x+1 = (x^5+1)/(x+1).$$

$$f(x^2) = (x^{10}-1)/(x^2-1) = (x^5-1)(x^5+1)/(x-1)(x+1) = f(x)\cdot f(-x).$$

$$f(x^4) = (x^{20}-1)/(x^4-1) = (x^{10}-1)(x^{10}+1)/(x^2-1)(x^2+1) = f(x^2)\cdot f(-x^2).$$

$$f(x^3) = (x^{15}-1)/(x^3-1) = [(x^5-1)/(x-1)][(x^{10}+x^5+1)/(x^2+x+1)] = f(x)\cdot(x^8-x^7+x^5-x^4+x^3-x+1).$$

Also solved by T. E. N. Eaton, and F. Howard. Many of the solutions stated $f(x^3) = f(x)f(-x^2)$, or else included the terms x^6 and x^2 in the last factor of $f(x^3)$ whereas division shows they are not present.

709. *Proposed by A. Pelletier, Ecole Polytechnique, Montreal.*

What are some of the various special cases of the problem of Pappus: Through three given points in the same straight line, construct three lines which shall form a triangle inscribed in a given circle. See problem 667 in June.

No solution or discussion has been received.

710. See problem 719 in the November issue.

PROBLEMS FOR SOLUTION.

721. *Proposed by Wm. B. Campbell, Philadelphia.*

Starting with two equal piles of material, a and b, one-third of that in a is transferred to b, then one third of b's new total is transferred to a, etc., indefinitely. A condition is manifestly approached where each pile alternates between 4/5 and 6/5 of its original condition, but give the general expression stating the fraction in each pile after n transfers.

722. *Proposed by Walter R. Warne, Pennsylvania State College, State College, Pa.*

Without using the trigonometric formula for the radius of a circumscribed circle, prove that in the ambiguous case of the triangle (wherein two sides and an angle opposite one of them are given), the two circumscribed circles of the two triangles are equal.

723. *From an examination paper sent in by John Lundberg, Goteborg, Sweden.*

The logarithm of a number to the base 10 equals the sum of its logarithms to two other bases, of which one base is one-tenth of the other base What are the two bases?

724. *Proposed by F. A. Cadwell, St. Paul, Minnesota.*

Three lines drawn from the vertices of a triangle ABC meet at a point O, either within or outside the triangle; AO, BO, and CO intersect BC,

AC, and AB respectively at H, F, and G. Prove (1) HI bisects ∠BIC, if F and G are points on AC and AB unproduced, or if on AC and AB produced; (2) FI bisects ∠BIC if F is on AC unproduced while G is a point on AB produced.

725. *For high school students. Proposed by the Editor.*

It appears that on a certain day last week Mrs. A started out to call on Mrs. B, and when she reached the domicile of the latter learned that Mrs. B had been gone just 11 minutes on her way to Mrs. A; and so Mrs. A at once returned to her home. Mrs. B had reached the mansion of Mrs. A 15 minutes after the latter had left; and so she retraced her steps toward her own home. On their return trips the ladies met at a point just midway between their homes. How many minutes does it take each of them to walk from one house to the other?

INCREASE IN IRON ORE.

The iron ore mined in the United States in 1920 amounted to 67,604,465 gross tons, an increase of 11 per cent over that mined in 1919. The shipments from the mines in 1920 were 69,281,341 gross tons, valued at $285,-006,327, which show increases of 23 per cent in shipments and 44 per cent in value. The average value per ton at the mines in 1920 was $4.11, as against $3.50 in 1919. The stocks of iron ore, mainly in Minnesota and Michigan, amounted to 11,378,794 gross tons, as compared with 13,097,-500 tons in 1919. These figures include only ore containing less than 5 per cent of manganese.

THE GREATEST RIVERS.

In the development of a new country the early settlers invariably follow the rivers from the coast. The inland waterways are of the highest importance to the welfare of a country, for they aid in the development of unsettled areas and materially reduce the expense for transportation of the necessities of life. Even though a stream may not be navigable for any craft larger than a canoe, it may serve as a guiding line to the first explorer.

There are comparatively few rivers whose exact lengths are known, but the following list of lengths of the principal rivers of the world has been compiled by the United States Geological Survey, Department of the Interior, from various sources and is probably as nearly accurate as any other to be had. The United States has the distinction of containing within its borders the longest river system in the world—the Mississippi-Missouri. Distances given in even hundreds of miles are approximate:

	Miles.
Mississippi (United States) from extreme source	2,486
Missouri (United States) from extreme source	2,945
Mississippi-Missouri (United States)	4,221
Nile (Africa)	4,000
Amazon (Brazil)	3,900
Ob (Siberia)	3,200
Yangtze-Kiang (China)	3,100
Amur (China)	2,900
Kongo (Africa)	2,900
Yenisel (Siberia)	2,800
Hwang (Yellow) (China)	2,700
Lena (Siberia)	2,600
Murray-Darling (Australia)	2,310
Yukon (Alaska and Canada)	2,300

SCIENCE QUESTIONS.

Conducted by Franklin T. Jones.

The Warner & Swasey Company, Cleveland, Ohio.

Readers are invited to propose questions for solution—scientific or pedagogical—and to answer questions proposed by others or by themselves. Kindly address all communications to Franklin T. Jones, 10109 Wilbur Ave., S. E., Cleveland, Ohio.

Please send examination papers on any subject or from any source to the Editor of this department. *He will reciprocate by sending you such collections of questions as may interest you and be at his disposal.*

INTERMEDIATE EDUCATION BOARD FOR IRELAND.

Examinations, 1920.

Pass and Honours.

JUNIOR GRADE.

EXPERIMENTAL SCIENCE, PHYSICAL SCIENCE COURSE.

Monday, 21st June.—Morning, 10 a. m. to 12 noon.

Pass Questions.

N. B.—The two sections immediately following are for Pass Candidates only. Honour Candidates will receive no credit for answering these. The questions for Honour Candidates will be found under the heading Honour Questions.

Not more than FIVE *questions are to be attempted. Of the* FIVE *attempted* TWO *must be chosen from Section I and* TWO *from Section II; the remaining question may be chosen from either section.*

The answers to Sections I and II must be enclosed in separate envelopes.

SECTION I.—PHYSICS.

1. How would you determine by experiment the relation between the circumference of a circle and its diameter?

If the diameter of a bicycle wheel is 30 inches, how many times will it revolve during a journey of 10 miles?

2. What do you understand by the centre of gravity of a body?

How would you determine by experiment the position of the centre of gravity of a sheet of cardboard?

Show how to deduce without experiment the position of the centre of gravity of a triangular sheet of cardboard of uniform thickness.

3. How would you verify that the apparent loss of weight of a body when immersed in a liquid is equal to the weight of the liquid it displaces?

The volume of a solid is 120 c. cs. What will be its apparent loss of weight when immersed in a liquid of density 1·15 grams per c.c.?

4. Explain how a mercury barometer measures the pressure exerted by the atmosphere. How would you set up a simple form of mercury barometer, and what precautions would you take in order that it might give accurate results?

5. Explain how you would determine the weight of a litre of air.

Why does a balloon ascend in the atmosphere?

6. How is a centigrade thermometer constructed and graduated?

Why should the bore of the tube of a thermometer be uniform?

SECTION II.—CHEMISTRY.

1. What do you understand by a crystalline substance? Describe the appearance of any three crystalline bodies you have used in the laboratory and mention the effect of heat on each.

2. Define oxide. Give examples of soluble and insoluble oxides. Show that the soluble oxides may be classified by the colour changes their solutions produce on litmus.

3. Describe carefully any method you have employed to find the percentage by volume of oxygen in ordinary air.

By what tests would you detect the presence of (*a*) carbon dioxide, (*b*) water vapour in the air?

4. Small pieces of sodium are added to water, what is the effect? How would you convert the liquid product resulting into a solution which consists of water and sodium chloride *only?*

5. How is hydrogen gas usually obtained? Sketch the apparatus you would employ if you wish to burn the gas and collect some of the product.

How is the product identified?

6. What do you understand by "The Indestructibility of Matter"? How do you reconcile this principle with the disappearance of a piece of glowing charcoal when placed in a large jar of oxygen?

Honour Questions.

N. B.—The two sections immediately following are for Honour Candidates only. Pass Candidates will receive no credit for answering these. The questions for Pass Candidates will be found under the heading Pass Questions.]

Not more than SIX *questions are to be attempted. Of the* SIX *questions attempted* THREE *must be chosen from Section I and* THREE *from Section II.*

The answers to Sections I and II must be enclosed in separate envelopes.

SECTION I.—PHYSICS.

1. How would you determine the diameter of a long piece of thin wire, being provided with a metre scale and balance?

How would you determine the width of the bore of a narrow glass tube, and how would you test the uniformity of the bore?

2. State the principle of the lever and describe how you would verify it.

A rod 12 feet long weighs 3 lbs. and it balances about its middle point when weights of 6 lbs. and 7 lbs. respectively are fastened to its ends. Where is the centre of gravity of the rod?

3. Give a reason for the fact that the apparent loss of weight of a solid when immersed in a liquid is equal to the weight of the displaced liquid.

The weight of a piece of metal in air is 100 grams and its apparent weight in water is 88 grams. What force would be necessary to push the metal beneath the surface of mercury?

[The density of mercury is 13.6 grams per c.c.]

4. Explain how the aneroid barometer acts.

Calculate the pressure of the atmosphere on the surface of the ground in lbs. per square inch when the mercury barometer stands at 30 inches, assuming that a cubic foot of water weighs 62.5 lbs. and that mercury is 13.6 times as heavy as water.

5. Describe any experiments you have made to study the relation between the volume and the pressure of a gas when its temperature is kept constant. How did you treat your observed numbers so as to arrive at the relation?

6. How would you show that a gas expands more than a liquid when heated, the pressure of the gas being kept constant? What happens if gas is heated in a closed vessel so that it cannot expand?

SECTION II.—CHEMISTRY.

1. Describe the effect of heat on wood: sketch the apparatus you would use to collect any liquid or gaseous products resulting from its distillation and contrast the products with those obtained when wood is heated with free access of air (burned).

2. How would you prove that the volume of oxygen obtainable from chlorate of potash is strictly proportional to the weight of salt heated? How would you allow for any changes in pressure or temperature that may occur in the course of your observation?

3. Constancy of composition is a condition of true chemical compounds, your experiments on air point to its being constant in composition, why then is air spoken of as a *mixture?* Explain fully.

4. Chalk mixed with an acid causes effervescence, but the product obtained by strongly heating chalk dissolves in acids without effervescence.

Explain this and point out how the heated product might be converted into its original condition; how would you find if the change is complete?

5 What are salts? Given some common salt, how would you prepare a strong solution of hydrogen chloride? What is the effect of hydrochloric acid on—

(*a*) washing soda,
(*b*) lime?

Contrast the properties of the salts produced.

6. Tin is heated for some time in a closed hard glass tube, how would you investigate the effects, (*a*) on the enclosed air, (*b*) on the metal?

What conclusion have you arrived at from experiments of this nature?

SECTION OF CHEMICAL EDUCATION.

The meeting was opened by Dr. Edgar F. Smith, chairman of the Section. He briefly discussed its purposes and aims. In part, he said that teachers should have a place to compare notes and that the purpose of the Section of Chemical Education was to furnish such a form. "A section on chemical education is just as important as a section on any division of science. I think in the end it will create greater unity in our teaching and lead to an improvement in the teaching of chemists."

"What General Chemistry Should be Taught in the First Two Years of College" was discussed by William McPherson and Harry N. Holmes. The courses differed somewhat as to order and detail, but each outline was of high merit.

Lyman C. Newell's paper on "Parallel Courses in General Chemistry" gave a detailed plan of the proper division of freshman classes. In brief, he expressed the opinion that parallel courses in general chemistry can be given profitably if certain conditions are fulfilled. Division into classes should be based mainly on entrance credit or non-direct in chemistry. The textbooks used must differ fundamentally in treatment but not essentially in scope. Methods of instruction in the non-credit class should follow traditional lines, though advantage may well be taken of every opportunity to incorporate facts, principles and theories needed in advanced courses. In the credit class, the instruction should provide an occasional opportunity to review the descriptive parts of general chemistry from a college standpoint but more especially a continuous opportunity to discuss and apply the modern interpretation of chemical change. Laboratory work should differ particularly in the manipulation needed and the interpretation demanded.

In the discussion which followed it was evident that the parallel courses were quite widely approved.

Herbert F. Davison contributed to the parallel course idea by giving in some detail the line of work used at Brown University for students who had had chemistry in high schools. The list of experiments which he gave were of a physical chemistry nature, and included a great deal of quantative work. He believed in giving detailed directions.

A. Silverman gave a paper on "The Systematic Care of Chemistry Students" in which he brought out many details which are overlooked or neglected by the average teacher.

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A symposium was given on "The Spirit of Research," by Professors Smith, Ellery, Noyes, Talbot, Olsen, and Dains. Time was the only thing lacking in making this of the highest importance and interest to all present. Dr. Ellery gave an outline for teaching the elements of research as it is being tried out at Union College. His discussion showed that he had given this matter much thought. His experiment is worth careful study, and one that will be watched with a great deal of interest. Dr. Noyes emphasized the importance of a thorough and broad foundation for those who are to take up research. He favored the chemistry major carrying out a piece of research in his senior year. This had a double purpose: first, to teach him how to find out what has been done on a problem by looking up literature, and, second, to interest him in contributing to the field of chemistry. The main goal is to get the student to like the work, but at the same time he must realize that his promotion will depend largely on what he can produce.

Dr. Talbot spoke briefly of the two possible kinds of research, the highly organized research and the less organized research. He said that each had its advantage. He emphasized the fact that the instruction in chemistry must be such that the student will realize that the subject is not a finished product, and that he wished to have a hand in extending the field. He pointed out the fact that instructors must be given some leisure time in which to do research, if the spirit of research is to be fostered in the department; but he said this means expense, and it is overhead expense that is holding up a great deal of excellent research today. He said that the research work must not be measured by credit hours. The undergraduate idea of credit is being carried over too much into the graduate work. The graduate work must be something that contributes to science regardless of time credit.

Dr. Olsen said that the first requisite for the spirit of research was to get the proper attitude of mind in the student. He believes that the spirit of research can be and should be taught early in chemistry education. Definite and nonflexible courses tend to kill the spirit of research. The student might better do less, and do well what he does. He thinks more emphasis should be put on original work which is of the student's own choice.

Dr. Dains points out the importance of the teacher's making it plain to the student that all chemical knowledge is the product of man's work and that the student has a very good chance in having a part in its future development. He believes that the spirit of research is contagious and hence the necessity of research being carried on in a department simultaneously with the teaching of chemistry. He clearly points out that all men are not capable of research.

Dr. Harrison Hale pointed out the different ways in which teachers might emphasize "America" in teaching chemistry. He said that this emphasis could best be kept in mind by becoming interested in (1) American chemical history and achievement, (2) magnitude of American resources, (3) fundamental importance of chemistry to America, and (4) American responsibility and opportunity.

Dr. Freas pointed out in a most interesting way that students need good equipment if good results are to be expected. Discussion was made in specific equipment of the building as ventilation, plumbing, steam, compressed air, light, hot plates, and hot water, etc. Time proved too short to give the audience as much information as they desired.

"Is the average college graduate in chemistry capable of taking up research? If not, why not?" This question was one that enlisted the keen

interest of both commercial chemists and teachers of chemistry. After the subject had been formally opened by M. L. Crossley, J. M. Weiss, H. D. Gibbs, and Dr. Rose in a most interesting and clear way, many extremely helpful suggestions were added by various members of the section. The general conclusions seem to be that some college graduates were not capable of research and never would be because they did not have the scientific view-point, while other college graduates failed because they lacked a thorough preparation in the fundamentals.

Some universities, for example, Johns Hopkins and Pittsburgh, are subjecting the college graduate to an examination before he is allowed to proceed with work leading to a doctor's degree.

"When Will the Teaching of Chemistry Become a Science?" was briefly discussed by N. E. Gordon. He tried to point out certain situations and conditions that would modify the original tendencies of the student in such a way as to make them energizing elements in chemical education.

The chairman, Dr. Smith, asked the pleasure of the section in regard to formal organization. A motion was made and seconded that the section be formally organized by a committee appointed by the chairman. An affirmative vote was unanimous.—[Neil E. Gordon, Secretary.

ARTICLES IN CURRENT PERIODICALS.

American Forestry, for October; *1214 16th St., Washington, D. C.; $4.00 per year, 40 cents a copy:* "Figure in Wood," Samuel J. Record, seventeen illustrations; "Pony Blimps for Fighting Forest Fires," Wallace Hutchinson, two illustrations; "Adirondack Forest Musings," E. A. Sterling, five illustrations; "The Ancient Forest of Camaldoli in Italy," Nelson C. Brown, nine illustrations; "The Mountain Lion, Ocelots, Lynxes and their Kin," R. W. Shufeldt, eight illustrations; "Forest Recreation Department," Arthur H. Carhart, eight illustrations; "Philanthropy or Efficiency," Arthur N. Pack, two illustrations; "Trees with Bright Autumn Foliage," F. L. Mulford, nine illustrations; "Chinese Forestry in 1919-1920," John H. Reisner, eight illustrations.

Geographical Review, for October; *Broadway at 156th Street, New York City: $5.00 per year, $1.25 a copy:* "Modes of Life in the Moroccan Countryside: Interpretations of Aerial Photographs," Jules Blache (1 map, 21 photographs); "A Contribution to the Geography of Albania," Ernest Nowack (3 maps, 2 block diagrams, 23 photographs); "The Cultural Transformation of the Copper Eskimo," Diamond Jenness (1 map); "Lower California and Its Natural Resources," W. M. Davis; "The Distribution of Population: A Constructive Problem," M. Aurousseau (6 maps); "The Cycle of Erosion in a Karst Region (After Cvijic[1])," E. M. Sanders (7 block diagrams, 2 diagrams, 2 photographs); "Human Geography," Edward Yeomans.

Nature Study Review, for September; *Ithaca, N. Y.; $1.50 per year, 20 cents a copy:* "Cornell Rural School Leaflet and Nature Study," and "Nature Study Outline," E. L. Palmer; "Wild and Garden Roses," R. W. Shufeldt; "Stalking the Cow," Elizabeth F. Burrall; "Bagworm Collections," Edith W. Warner; "An Interesting Boulder," C. J. Kimmerle.

Photo-Era, for September; *Boston, Mass.; $2.50 per year, 25 cents a copy:* "A Pilgrimage to Wolfeboro, New Hampshire" (Part II); "Simple Facts in Regard to Actinism of Light;" "Adapting a Verito to a Graflex;" "The Pin-Hole and the Pictorialist;" "Practical Observations of a Photo-Finisher."

Popular Astronomy, for October; *Northfield, Minn.; $4.00 per year:* "Bright and Dark Nebulae Near—Orionis Photographed With 100-Inch Hooker Telescope" (two plates), John C. Duncan; "The Daily Influence of Astronomy," W. W. Campbell; "Proposed Periods in the History of Astronomy in America" (Concluded), W. C. Rufus; "Notes Concerning the Pons-Winnecke Comet and Meteors" (Plate), O. H. Truman; "Eclipse of the Moon, 1921, October 16," W. F. Rigge; "The Effect of the Baro-

metric Gradient on Meridian Observations," Charles C. Wylie; "A Modern Theory of Spiral Nebulae," George B. Hufford; "Miscellaneous Notes and Data Relative to Novae," C. O. Lampland; "Twenty-sixth Meeting of the American Astronomical Society."

National Geographic Magazine, for November; *Washington, D. C.; $4.00 per year, 50 cents a copy:* "Through the Heart of Hindustan," Maynard O. Williams, 29 illustrations; "The Marble Dams of Rajputana," Eleanor Maddock, 13 illustrations; "The Empire of Romance—India," 16 illustrations, in color; "Outwitting the Water Demons of Kashmir," Maurice P. Dunlap, 9 illustrations; "A Pilgrimage to Amernath, Himalayan Shrine of the Hindu Faith," Louise A. Jessop, 29 illustrations.

Scientific Monthly, for October; *Garrison, N. Y.*; $5.00 *per year*, 50 *cents a copy:* "The Constitution of Matter," Sir T. Edward Thorpe; "The Laboratory of the Living Organism," Dr. M. O. Forster; "Experimental Geology," Dr. J. S. Flett; "Some Problems in Evolution," Professor Edwin S. Goodrich; "Applied Geography," Dr. D. G. Hogarth; "Scientific Idealism," Dr. William E. Ritter; "Field Crop Yields in New Jersey from 1876 to 1919," Harry B. Weiss; "The Play of a Nation," Professor G. T. W. Patrick; "Evariste Galois," Dr. George Sarton; "Mars as a Living Planet," G. H. Hamilton.

School Review, for October; *University of Chicago Press;* $2.50 *per year*, 30 *cents a copy:* "Junior-College Courses in 1920-21," Leonard V. Koos; "Some Facts Regarding Sex Instruction in the High Schools of the United States," Newell W. Edson; "An Experiment with a Course in General Technology," C. T. Newman; "Our Complex Civilization and the Genius of Its Youth," Harry H. Moore.

Torreya, for September-October; *New York Botanical Garden, Bronx Park, New York City;* $1.00 *per year*, 30 *cents a copy:* "The Forest Flora of Grassy Sprain Ridge," G. T. Hastings; "Some Introduced Plants of Utah," A. O. Garrett; "The J. Roberts Lowrie Herbarium," F. D. Kern; "Cynosurus echinatus in Oregon," R. V. Bradshaw; "The Boy Scouts and Conservation of Wild Flowers," G. T. Hastings.

BOOKS RECEIVED.

Modern Applied Arithmetic, by R. R. Neely, Peoria, Ill., and James Killius, Johnstown, Pa. Pages xi+156. 13.5×19 cm. Paper. 1921. 70 cents. P. Blakiston's Son & Co., Philadelphia, Pa.

Courses of Study in Geography, 20c; Home Economics, 15c; Hygiene, 20c; General Science, 25c; English, 50c; Fine and Applied Art, 15c; Drawing and Applied Art in Grades One to Six, 20c; and Art, 15c; in the Cleveland, Ohio, Schools, by Cleveland teachers. Board of Education, Cleveland, Ohio.

Bushing's Loose Leaf Laboratory Manual Note Books. 21.5×27.5 cm. 1921. No. 1, 35c; No. 2, 45c. The Bruce Publishing Co., Milwaukee, Wis.

Mechanical Drawing, first year, by Willard U. Enneling, Ferdinand A. P. Fischer and George G. Greene of the Chicago Schools. 78 pages. 15 plates. 16×21 cm. Paper. 1921. 45 cents. The Bruce Publishing Co., Milwaukee, Wis.

Facilities for Foreign Students in American Colleges and Universities, by Samuel P. Copen. Bulletin No. 39. 279 pages. 15×23 cm. Paper, 15 cents. Government Printing Office, Washington, D. C.

Report of the High School Visitor, by H. A. Hollister. 68 pages. 14×22.5 cm. Paper. The University of Illinois, Urbana.

THE DALTON, No. 2100

BOOK REVIEWS.

Chemical Reactions and their Equations, by Ingo W. D. Hackh, Professor of Biochemistry, College of Physicians and Surgeons of San Francisco. First edition. Pages viii+138. 19 x 13 x 1 cm. Several figures. Cloth. 1921. $1.75 net. P. Blakiston's Son & Co., Philadelphia.

This volume was written expressly "in order to supply students with necessary material and to expound the general principles of balancing equations." The book is a monograph dealing with the teaching of the use and the significance of chemical symbols, formulae and equations. The chapters are entitled as follows: I—Symbols: II—Formulas; III—Equations (Involving no Oxidation and Reduction); IV—Equations (Involving Oxidation and Reduction); V—Reactions and their Control) VI—Types of Chemical Reactions and Equations. An Appendix is provided with: I, Key to Nomenclature with a List of Radicals, Ions and Valence Numbers; II, Displacement Series of the Elements; III, Periodic System and Classification of the Elements; IV, Solubility Table of Compounds; V, Preparation of Salts. There is furnished a Key to the Equations and an index and Glossary of Chemical Terms.

At the ends of the chapters questions and problems for practice are provided. On casual examination the book seems to be very well planned and the presentation of the subject matter seems well done. College students should be able to use the book by themselves to good advantage and the secondary school teacher of chemistry will find it of service in guiding his instruction in these topics.

F. B. W.

The Derivation and Standardization of a Series of Diagnostic Tests for the Fundamentals of First Year Algebra, by Harl Roy Douglass, Professor of Education in the University of Oregon. Pages, 48. 17x25 cm. Paper, $1.00. The University Press, The University of Oregon.

The purposes of this study are: (1) To determine what seems to be the fundamental formal processes in first year algebra as commonly taught in the secondary schools; (2) to select for each process a number of problems; (3) to standardize the results obtained by giving these problems to a large number of first year high school pupils; and (4) to point out the uses and values, and limitations of tests so devised.

Several of the standard tests are discussed and compared, and the value of such tests pointed out. H. E. C.

The Constitution of the United States of America. 39 pages. Paper. 1921. Government Printing Office, Washington.

This compact, little book, containing the Constitution of the United States, together with the nineteen amendments, is just the thing to put into the hands of pupils of all grades. It may be had from the Government Printing Office at the expense of five cents per copy.

C. H. S.

A Text Book of Organic Chemistry, by Joseph Scudder Chamberlain, Ph.D., Professor of Organic Chemistry, Mass. Agricultural College. First edition. Pages XLIII+959, 20x15x4 cm. Myriads of graphic and other formulas. Cloth. 1921, $4 net. P. Blakiston's Son & Co.

The author of this new college text in organic chemistry is attempting to respond to the large new demand for opportunity to study organic, chemistry that the war has aroused. He modestly "trusts, therefore, that a new text may be acceptable, and that there may be found in it as much individuality as is possible in a book dealing almost wholly with well established facts and theories."

The text deals mainly with the facts and theories of organic chemistry rather than with the industrial applications of these fundamentals but from time to time the author points out important reactions or types of reactions that have become the bases of industrial processes. In a few cases something of the industrial procedure is given but not in minute detail. This is probably as it should be for the student in any case must learn to apply his facts and theories largely for himself and before he can apply them he must learn them.

The size of the book precludes any very detailed account of its content and order of treatment. The text is broadly divided into Part I, dealing with the non cyclic compounds, and Part II, treating of the cyclic compounds. In Part I the aliphatic series is first taught beginning with the simpler saturated compounds. The hydrocarbons, their monosubstitution products, and the oxidation products of their alcohols are considered in that order. Then come the simpler unsaturated hydrocarbons, and polysubstitution products, etc. Part II is broadly divided into two sections dealing with the ali-cyclic and the hetero-cyclic compounds.

The preparation of a text book of this character is a monumental task and the author is to be congratulated on the very worthy character of the book. The English expression is correct and pleasing so that the text is as easy to read as any very technical text can be. From a very casual skimming of its pages we would say that very few typographical errors have been allowed to remain in it.

Up to date products such as the various types of artificial silk and the newer high explosives are well treated so there is no longer any excuse for the colored infantryman to translate T. N. T. as "travel, nigger, travel!"

A two-page bibliography of books of reference is provided and an appendix on "The Separation, Purification, Identification, Analysis and Determination of the Molecular Weight of Organic Compounds."

The reviewer wishes the student well who undertakes to absorb and assimilate any considerable part of modern organic chemistry and assures him that once it is safely "passed up" he will find little effort necessary to promptly forget much of it unless he is forced to use it in his business. However, the text under consideration seems so systematic and so clear in its presentation of the subject matter that it is to be hoped that many of our Professors of Organic Chemistry will use it.

F. B. W.

Plane and Solid Analytic Geometry, by W. F. Osgood, Ph.D., LL.D., Perkins Professor of Mathematics, and W. C. Graustein, Ph.D., Assistant Professor of Mathematics in Harvard University. Pages xvii+614, 13 x 19 cm. 1921. The Macmillan Company, New York.

The point of view from which this new book is written is indicated by a paragraph in the preface which states that the object of an elementary college course in analytic geometry is to acquaint the student with new and important geometrical material, and to provide him with powerful tools for study of geometry and pure mathematics, and for the study of physics in the broadest sense of the term, including engineering.

The geometrical material is presented in the simplest and most concrete form and illustrated, wherever possible, by its relation to physics. Each new subject is introduced by the discussion of a simple, typical case, and the problems and exercises are carefully graded. This treatment of analytic geometry is unusually extensive but it is so arranged that the instructor can make a selection of topics to fit his own needs.

H. E. C.

Plane Trigonometry, by Arnold Dresden, Assistant Professor of Mathematics in the University of Wisconsin. Pages vii+110, 14.5 x 22 cm. 1921. John Wiley and Sons, Inc., New York.

To emphasize the importance of the function concept in elementary mathematics by presenting it in a textbook in trigonometry is the leading motive of the author in writing this book. He considers he has done enough as a first step by a somewhat detailed study of the graphs of the trigonometric functions and of the inverse functions. Problem material from the applied sciences has been carefully excluded in order that the fundamental concepts of trigonometry might be stressed and only problems which connect with the student's actual experience be given.

H. E. C.

Analytic Geometry, by C. I. Palmer and W. C. Krathwohl, Associate Professors of Mathematics in the Armour Institute of Technology. Pages xiv+347, 13 x 19 cm. 1921. McGraw-Hill Book Co., Inc., New York.

Throughout the text the great central idea of passing from the geometric to the analytic and *vice versa* is held consistently. Transformation of coördinates is given early and used frequently in all the work. Numerous illustrative examples are worked out in detail. The conic sections are all treated from the starting point of the focus and directrix definitions. The empirical equation is dealt with much more completely than is usual, so that one is enabled to solve the average problem in empirical equations. The elements of calculus are treated in forty-five pages with excellent applications in getting tangents and areas. The chapter on solid geometry gives ample preparation for course in calculus.

H. E. C.

An Introduction to Mathematical Analysis, by F. L. Griffin, Ph. D., Professor of Mathematics in Reed College, Portland, Oregon. Pages viii+512, 13.5 x 19.5 cm. 1921. $2.75, Houghton Mifflin Company, Boston.

The writer has little hesitation in saying that this is in his opinion the best text combining trigonometry, college algebra, analytic geometry, and calculus he has examined. It includes all the parts of these subjects necessary for ordinary applications in the sciences, and correlates the material so closely that the student can understand how to apply his knowledge in solving problems. The frequent and full discussion of difficulties and obscure points not readily understood by the learner are interesting and illuminating, since the author writes as a good instructor talks in the classroom. As a reference book for teachers, students, and those in the applied sciences who must consult handbooks, this textbook will be found most satisfactory.

H. E. C.

School Arithmetics, by George Wentworth and David Eugene Smith. Book I. Pages v+282, 14.5 x 19 cm. 1920. 72 cents. Book II. Pages vi+298. 76 cents. Book III. Pages vi+346. 92 cents. Ginn and Company, Boston.

These books cover the work of Grades I-IV, V-VI, and VII-VIII, respectively, though it is suggested that each school should adjust the work to meet its own peculiar conditions. They stand for good, well-arranged mathematics which appeals, to the pupil's human interests; and they furnish the teacher with the labor-saving material needed in a thorough course in arithmetic, and suggest fields for the development of interesting local problems and appropriate projects.

H. E. C.

CONTENTS *for* DECEMBER, 1921

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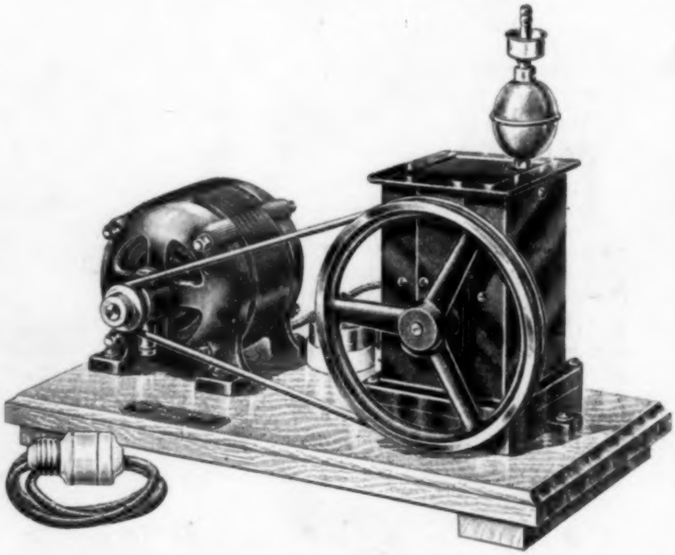

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For a complete report of tests made on this pump by the University of Illinois, see School Science and Mathematics for October, 1921, page 617.

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